Electronic Services - Los Angeles
M126646X

Instructions

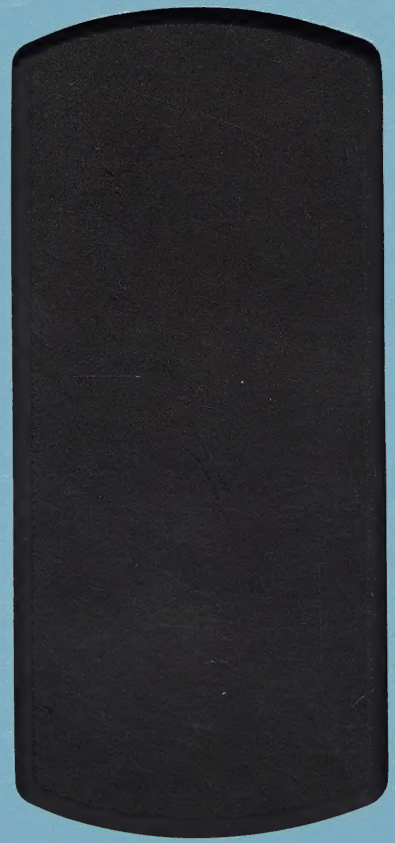
CLOSED CIRCUIT TELEVISION CAMERA

MODELS
4TE26A1
4TE26B1

EBI-6286

MP MASTER
MA32572

GENERAL ELECTRIC



453 SCOPE

INSTRUCTIONS

CLOSED CIRCUIT TELEVISION CAMERA

MODELS
4TE26A1
4TE26B1

EBI-6286

CLOSED CIRCUIT TELEVISION BUSINESS SECTION
VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION
GENERAL ELECTRIC COMPANY
ELECTRONICS PARK, SYRACUSE, N.Y.

10/69 (350) Printed in U.S.A.

GENERAL SERVICE INFORMATION

SAFETY NOTICE

WARNING

VOLTAGES USED FOR THE OPERATION OF THIS EQUIPMENT ARE DANGEROUS TO HUMAN LIFE.

This instruction manual is written for the general guidance of maintenance and service personnel who are familiar with and aware of the dangers of handling electric and electronic circuits. It does not purport to include a complete statement of the safety precautions which should be observed in servicing this or other electronic equipment. The servicing of this equipment by inadequately trained or inexperienced personnel involves risks to such personnel and to the equipment for which the manufacturer can not accept responsibility. Personnel servicing this equipment should familiarize themselves with first-aid treatment for electrical burns and electrical shock.

PRODUCTION CHANGES

From time to time it becomes necessary to make changes in the equipment described in this book. Such changes are made to improve performance or meet component shortages. Changes in the equipment as they affect the instruction book are listed on a production change sheet added at the back of this book. The serial number of the first unit for which the change became effective is listed at the top right corner of the change sheet. If no production change sheet is included, no changes have been made in the equipment. Note that changes and/or corrections have not been incorporated in the affected parts list, schematics, and/or text.

This information is provided as a servicing aid; it should not be used to modify earlier equipments to incorporate later revisions except under specific instructions. Please mention the serial number in any correspondence.

REPLACEMENT PARTS

The parts list contained in this book includes all principal replacement parts. The symbol numbers are the same as those appearing on schematic and other drawings. Whenever possible, replacement parts should be obtained from a local electronics supply dealer. If it is necessary to order a part (other than a tube or transistor) from the General Electric Company, please include the symbol number, description, and drawing number of the part and model number of the unit. Orders may be sent to the General Electric Company, Visual Communication Products, Bldg. 7, Rm 321, Electronics Park, Syracuse, N.Y., 13201. Phone Area Code 315, 456-3598.

REPLACEMENT TUBES AND TRANSISTORS

In all cases replacements must be ordered from a local distributor.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Closed Circuit Television Business Section
VISUAL COMMUNICATION PRODUCTS DEPARTMENT

GENERAL ELECTRIC
ELECTRONICS PARK, SYRACUSE, N. Y.

EBI-18 (1M)

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EBI-3711 Fundamentals of Television and Essentials of Optics
EBI-3781 Fundamentals of the Vidicon Tube and Transistor Characteristics
RETMA (EIA) Resolution Chart

E.B.I. 6286

ADDENDUM

Add the following to Technical Summary on Page #3:

REMOTE DRIVE INPUTS

Negative going 3.0 - 5.0 volts

(75 ohm termination as required)

Add asterisk and note to Environmental Temperature Specification on Page #4:

"*0°C to +50°C when using internal sync generator.

1/16/70

CLOSED CIRCUIT TELEVISION CAMERA

MODELS
4TE26A1
4TE26B1

INTRODUCTION

The General Electric Closed Circuit Television Camera, Models 4TE26A1 and 4TE26B1, designed for general use in a variety of closed circuit television systems requiring high resolution, stability, and picture fidelity, produces a composite television output signal of 1.0 volt peak-to-peak which can be displayed on any standard television monitor. An accessory sync generator is available for positive 2:1 interlace. Other accessories, listed below, are available on separate order.

EQUIPMENT

The Camera, fully self-contained, may be ordered with or without a vidicon tube (several options available). The Camera lens, cable, and other items must be ordered separately. When, however, a complete camera chain is ordered, it will be assembled with any associated equipment, tested, and shipped with any ordered accessories installed.

The Model 4TE26A1 is a local-control unit, with all controls accessible at the rear of the Camera.

The Model 4TE26B1 is the same as the 4TE26A1, except that operational setup controls are located on a Remote Control Box at a remote point.

ACCESSORIES

The following accessories are available on separate order:

1. Sync Generator Kit, PL-7399144G1, for positive 2:1 interlace. Supplied are the sync generator board, PL-7699914G1, and the materials required for field installation of the unit.

2. Alignicon, PL-7782048G2, designed for use in aligning the preamplifier and the video amplifier of General Electric CCTV Cameras.

3. Remote control 19-inch rack adapter.

4. Remote control cable.

5. Spanner wrench, PL-7167210G3.

TECHNICAL SUMMARY

ELECTRICAL

Input Voltage

117 volts a-c ± 10%, 50/60 Hz.

Input Power

20 watts.

Vertical Sweep Rate

50/60 Hz.

Horizontal Sweep Rate

15.625, 15.75, or 20.25 kHz.

Scanning

Crystal-controlled random interlace or positive 2:1 interlace from optional internal or external sync generator. Scanning rate 525 or 675 lines per frame (60 Hz) or 625 lines (50 Hz).

Resolution

800 lines center (minimum), 500 lines corners (with Type 7735B vidicon and 525/30 scanning). 600 lines corners with separate mesh vidicon.

Resolution Stability

Full resolution over rated temperature range and line voltage range.

Type of Sync and Blanking Waveform

In accordance with EIA Standard RS-330 (self-contained unit) or EIA Standard RS-170 (when driven by an external sync generator complying with RS-170).

Gray Scale Rendition

Will resolve 10 shades of gray (including white background) from EIA Television Resolution Chart with gray scale overlay strips.

Geometric Distortion

Within ± 2% of picture height.

H Scan Frequency Source

Crystal oscillator derived, external (optional) or AFC.

V Scan Frequency Source

Line derived or synchronized with H frequency (optional).

Aperture Correction

Selectable to provide 100% response at 400 to 500 lines.

Sensitivity

0.714-volt video with 0.05 foot-candle faceplate illumination (0.5 foot-lambert scene brightness, using one-inch f1.4 lens) and full resolution performance.

Automatic Light Range

Automatically maintains video output constant to within ± 10% measured from black level to peak white over light range from 1000 foot-candle faceplate illumination maximum tube rating down to 0.05 foot-candle (20,000 to 1 range).

Signal Transmission Distance

Depends on cable.

Signal Output

1.0-volt peak-to-peak composite (0.714 ± 0.1 volt video, 0.286 ± 0.1 volt sync), black negative 75-ohm source impedance, or 0.714-volt noncomposite video (user option).

RF Output

None.

Camera Tube Type

Type 7735B, 8507, 8541, or other one-inch diameter vidicon, including lead oxide types, high or low heater.

MECHANICAL

Dimensions

Length: 12½ inches
Width: 6 inches
Height: 3-3/4 inches
Weight: 11 pounds

Lens Mount

Type "C"

Camera Mounting

Two $\frac{1}{4}$-20 holes in base.

Output Connector

Video: BNC
Remote Control: Amphenol 67-06C14-12 (Model 4TE26B1 only).

Input Connectors

BNC, H, V, and sync (remote drive models).

Power Cord

Wired-in, eight-foot long, three-conductor, with three-pin grounding plug.

ENVIRONMENTAL

Temperature: -20 to +60 C at 95% relative humidity.
Altitude: 10,000 feet above sea level.

TRANSISTOR COMPLEMENT

Camera Case

1 Type B5031 (Q1)

Video Board

1 Type 2N5245 (3Q1)
7 Type 2N4916 (3Q2, 3Q4, 3Q7, 3Q11, 3Q12, 3Q13, 3Q14)
1 Type 2N5181 (3Q3)
1 Type 2N5163 (3Q5)
4 Type 2N3663 (3Q6, 3Q9, 3Q10, 3Q20)
2 Type 2N4256 (3Q8, 3Q21)
1 Type 2N3403 (3Q15)
1 Type 2N5176 (3Q16)
1 Type 2N5138 (3Q17)
2 Type 2N3415 (3Q18, 3Q19)
3 Type 2N3646 (3Q22, 3Q23, 3Q24)

Power-Sweep Board

17 Type 2N3415 (4Q1, 4Q2, 4Q3, 4Q9, 4Q12, 4Q13, 4Q16, 4Q17, 4Q18, 4Q19, 4Q20, 4Q21, 4Q22, 4Q23, 4Q24, 4Q26, 4Q27)
1 Type 2N4256 (4Q4)
1 Type D28D10 (4Q5)
5 Type 2N5138 (4Q6, 4Q8, 4Q15, 4Q25, 4Q28)
1 Type 2N4918 (4Q7)
2 Type MPS6518 (4Q10, 4Q11)

1 Type 2N4921 (4Q14)
1 Type 2N3403 (4Q29)

DESCRIPTION

MECHANICAL

1. Construction

The Camera, which presents a horizontal profile, rectangular in shape and wider than it is high, is a simplified but ruggedized structure consisting of front and rear die cast end caps fastened to the ends of an aluminum extrusion. This "base" extrusion is covered by a second U-shaped extrusion to fully enclose the unit.

Internally, a compartment is formed by an upright section, which is part of the main base extrusion, and by the attachment of an identical separate upright section on the opposite side.

There are three circuit boards, one of which is mounted flat on the base to provide interconnection between the two main boards, video and power-sweep, which are mounted in an upright position to the outside of the extruded sections.

The focus-coil/deflection-yoke assembly is mounted at the front end of the internal compartment and the power transformer at the rear. Two ball-bearing races extruded into the base section are used with a separately extruded yoke cradle to provide the optical focus mount. This cradle, or slide, is provided with two adjustable inserts in which the mating ball-bearing races are extruded. These inserts permit adjustment of the proper width at assembly to accommodate extrusion tolerances and to insure correct bearing fit.

The base section also includes an extruded guide for the focus rod, which threads into a nylon nut captivated in the yoke cradle.

Also extruded at the top and bottom of the compartment is a flute which accepts a thread-rolling screw for the attachment of the end caps.

A step is cast into the end caps to seat the cover, and a tongue and groove are provided on the base extrusion to mate the cover to that section.

Operational controls are mounted on a sub-panel that fits within the inner compartment and attaches to bosses on the rear end cap with thread-cutting screws. These controls are recessed and screwdriver-activated.

Provision is made for optional mounting of an internal sync module, which fastens, with a mounting cradle, within the inner compartment over the transformer at the rear of the Camera. The cradle is so fastened that the whole assembly can hinge up to allow access to the inner compartment.

2. Controls

The normal operating controls are located at the rear of the Model 4TE26A1 Camera or are provided on the accessory Remote Control Box for the Model 4TE26B1 Camera. The T(arget), B(eam), F(ocus), and S(etup) controls on the rear panel of the local-control Camera are recessed screwdrive adjustments; similar controls on the Remote Control Box for the 4TE26B1 are knob adjustments.

A toggle switch is provided to switch between AUTOmatic or MANual TARGET modes. This control is remoted.

The power ON-OFF switch, which is of the slide type and illuminated, remains on the rear panel of the 4TE26B1 Camera but is wired through a relay for remote actuation.

An additional screwdriver adjustment of optical focus is located at the bottom of the rear panel of the Camera.

3. Servicing

The cover is removed by loosening four captive screws on the cover bottom, thus fully exposing the two main circuit boards, which are clearly marked with component symbols and outlines. The boards are held in place by five screws and plug into edge connectors on the interconnection board. The removal of four screws on the rear panel and two on the Camera bottom allows that assembly to drop down and afford access to the control potentiometers, power switch, and fuse.

Access to the interconnection boards, though somewhat less convenient, is relatively easy except for the circuit runs on the bottom side, a check of which requires removal of the board.

4. Electrical Connections

AC power is obtained through a conventional eight-foot-long, three-wire cord with grounding plug, which is fastened to the rear panel.

The video output is on a BNC connector. Camera models allowing drive and sync inputs also use BNC connectors.

Supplied with the Model 4TE26B1 Camera is a 12-pin female connector, Amphenol 67-02E14-12P.

Internal electrical connections are made with edge connectors for the two main circuit boards. In addition, quick-disconnect pins and receptacles are used for the deflection and focus coils, for sync board tie-in to the interconnection board, and for the attachment of control potentiometer leads to the interconnection board. These same pins are used on the video board for target input and external/internal sync selection, and on the power-sweep board for H and V drive internal/external selection.

ELECTRICAL

The three printed circuit boards used in the Camera are 1/16-inch fiberglass, double-sided, with plated-through holes. The video and power-sweep boards assemble to edge connectors mounted on the interconnection board. The optional sync generator board is of identical construction.

Extensive use is made of quick-disconnect pins and receptacles for flexibility of application and for ease of assembly and servicing. They are used for the connection of the focus-coil/deflection-yoke circuits to the interconnection board and for connection of the Camera rear panel controls. An additional pin on the interconnection board permits choice of one of two transformer filament windings, depending upon whether a 600- or 90-ma heater vidicon is used.

The video board uses quick-disconnect pins for the target input, video output, and for the optional feeding in of external sync. Furthermore, the aperture and gamma correction circuits are optionally selected by the use of a jumper with a disconnect pin and receptacle.

Quick-disconnect pins are used on the power-sweep board for connection of horizontal and vertical pulses. Excepting a few, the silicon transistors are soldered in for increased reliability. The exceptions include the field-effect-transistor (FET) preamplifier, which uses a socket to allow selection for best S/N characteristics; the sync adder stage; and the external sync inverter stage to permit selection of either external sync, camera developed sync, or a non-composite output. The keyed clamp transistor also uses a socket to permit easy removal for checking bandpass. In addition, sockets for the AGC transistor and vidicon blanking inverter allow selection of transistor characteristics.

For circuit descriptions, refer to the THEORY AND CIRCUIT ANALYSIS section.

INSTALLATION

Refer to Fig. 1.

Unpack the Camera from its shipping carton and mount it on a tripod, or other suitable mounting, with the $\frac{1}{4}$-20 inch mounting screw. Use one of the two tapped $\frac{1}{4}$-20 inch holes in the base of the Camera. Depending upon the type of lens and accessories used, select the hole that gives the best balance.

CAUTION

DO NOT USE $\frac{1}{4}$-20 SCREWS LONG ENOUGH TO EXTEND UP INTO THE INTERCONNECTION BOARD, SINCE DAMAGE MAY RESULT.

The Camera is shipped with the vidicon tube installed. (For removal and replacement of the vidicon, refer to the MAINTENANCE section.) If necessary, clean the face of the tube with a lens tissue before installing the Camera lens.

ELECTRICAL CONNECTIONS

For the operation of the Camera, insert the line cord plug into a three-conductor grounding type a-c outlet delivering a nominal 117-volt, 60-hertz alternating current.

Connect the video output jack to the display monitor. Proper operation of the Camera requires termination of the video output signal in 75 ohms at the last display monitor.

CAMERA CONVERSION TO POSITIVE 2:1 INTERLACE

Refer to Figs. 2, 3, and 4.

The Sync Generator Kit, PL-7399144G1, is available as an accessory for converting the Camera to positive 2:1 interlace. When the customer orders the sync generator with the Camera, it is installed in the Camera and completely tested and adjusted before shipment.

To meet the demands of an occasional field installation, the procedure for installing the Kit are covered in the applicable instruction book.

OPERATION

CONTROLS AND ADJUSTMENTS

1. Camera

NOTE

All of the controls and adjustments listed below are located on the rear panel of the local-control Camera (4TE26A1). With the remote-control Camera (4TE26B1), the ON slide switch remains on the rear panel, but is wired through a relay for remote actuation by a similar switch at the Remote Control Box. The Control Box also includes the remainder of the controls listed for the local-control Camera. In both Cameras, the recessed screwdriver adjustment for optical FOCUS is located at the bottom of the rear panel.

Name	Symbol	Function
ON power (with indicator light)	2S1	Activates or de-activates the Camera. With power switched ON, the indicator lamp is lit.
TARGET AUTO/MAN	2S2	Selects the automatic or manual mode of target control.
T(arget)	2R1	With the AUTO/MAN switch in the MAN position, sets the d-c voltage applied to the target.

Name	Symbol	Function
B(eam)	2R2	Adjusts the voltage on grid 1 (G1) of the vidicon and controls the amount of beam current being used to discharge the vidicon target. The control is so adjusted that the vidicon target is discharged.
F(ocus) (electrical)	2R3	Adjusts the voltage on grid 3 (G3) of the vidicon and is set for the sharpest image.
S(etup) (pedestal)	2R4	Sets the d-c level of the video clamp.
FOCUS (optical)		Adjusts the optical focus of the Camera.
2. Video Board		
GAIN	3R19	Sets the gain of the video amplifier. For normal operation, the setting should be one-half of full gain. Under extremely low light-level conditions, the control can be set more clockwise; however, noise as well as signal will be amplified at higher gain. If the light level will always be high, the GAIN control may be set more counterclockwise than mid-position (as far back as 9 o'clock) to obtain a less noisy picture.
AUT GAIN	3R21	Automatically controls video gain with changes in light level.
AUTO/MAN TARGET	3R62	In the AUTO TARGET mode, produces an equivalent decrease in target voltage with increase in light, thus resulting in a constant signal output from the Camera. In the MAN TARGET mode, allows the operator to adjust the target as desired.

Name	Symbol	Function
3. Power-Sweep Board		
HOR BLK WIDTH	4R11	Adjusts the horizontal system blanking width.
HOR SIZE	4R15	Adjusts the horizontal sweep size by varying the amount of d-c voltage at the collector of the horizontal sweep transistor.
HOR CTR	4R21	Adjusts the horizontal sweep centering.
VERT BLK WIDTH	4R64	Adjusts the basic vertical system blanking width.
VERT CTR	4R82	Adjusts vertical sweep centering.
VERT SIZE	4R86	Adjusts the size of the vertical sweep by varying the amount of feedback in the vertical amplifier.

INITIAL OPERATION

The procedure outlined below is recommended for initial operation of the Camera. It is assumed that the electrical connections are correct, the Camera is plugged in, the ON power switch is off (indicator lamp is off), and a lens is in place. (Set the lens for f1.9 to f3.5 for normal indoor scenes or for f5.6 to f8 for normal outdoor scenes.)

CAUTION

NEVER ALLOW AN IMAGE OF THE SUN TO BE FOCUSED ON THE PHOTO-CONDUCTIVE LAYER OF THE VIDICON AT ANY TIME. DO NOT UNDER ANY CIRCUMSTANCE AIM THE CAMERA AT THE SUN WITH POWER ON OR OFF.

1. Apply power to the Camera by sliding the ON power switch to ON (the indicator lamp will light). Set the TARGET selector switch to the MAN(ual) position and adjust the TARGET control to its midrange position. Allow three minutes for the vidicon and preamplifier to warm up.

2. Turn the B(eam) control clockwise until a picture appears on the display monitor.

3. Set the lens focus ring to infinity and, observing a distant object, optically focus the picture on the monitor by setting the screwdriver FOCUS adjustment at the rear of the Camera.

4. Set the f stop on the lens used to the lowest value consistent with the depth of field required and the light available.

5. Set the T(arget) control to obtain a 1.0-volt composite output.

6. Readjust the B(eam) control, if necessary, to a point well above beam starving. As a rule, if the T(arget) control setting is changed, the B(eam) control will require readjustment. If the AUTO TARGET mode is to be used, set the B(eam) control more clockwise than for the MANual TARGET mode.

7. Increase the video gain by adjusting 3R19 (located inside the Camera on the video board) if the scene illumination is very low. Normally, leave this GAIN control set at the 12 o'clock position.

8. Set the display monitor CONTRAST and BRIGHTNESS controls for the most pleasing picture.

AUTOMATIC TARGET ADJUSTMENT

Set the AUTO TARGET adjustment control so that the video amplitude is between 0.7 and one volt peak-to-peak.

Adjust the B(eam) control slightly more clockwise than necessary to just discharge the target. This permits adequate beam current over a range of target voltages.

ROUTINE OPERATION

Whenever the Camera is placed in operation, allow for a three-minute warm-up period. This permits the vidicon to become stabilized.

Once the preliminary adjustments have been made, routine operation of the Camera becomes very much simplified. Unless it is obvious that the Camera sweep controls are out of adjustment, do not change their settings. If adjustments must be made, perform them only according to the procedure outlined in the MAINTENANCE section. Large changes in scene illumination may require resetting either the lens iris or the T(arget) control. The B(eam) setting must be readjusted when the T(arget) setting is changed, with the TARGET selector switch in the MANual position.

THEORY AND CIRCUIT ANALYSIS

POWER-SWEEP BOARD

Refer to Figs. 5, 6, and 7.

The power-sweep board contains the low-voltage regulated power supplies, focus current regulator, horizontal and vertical timing systems, and yoke drivers.

The +20 volt regulated supply is a feedback type using a differential amplifier, Q16 and Q17, and a low-temperature-coefficient zener diode, CR17. The diode controls not only the basic power supply but also the focus current regulator.

The amplified difference between a sample of the output voltage and the reference diode is applied to emitter follower Q18 and then to the pass transistor, Q1, located on the main chassis.

The -20 volt supply uses the stable +20 volt supply as a reference. In this feedback amplifier, the output sample is compared with ground potential by Q8, and the amplified difference is fed into the pass transistor Q7. There are no adjustment potentiometers in either supply. To compensate for the zener voltage tolerances, R56 is selected in test to fix the +20 supply precisely.

The stable zener diode, CR17, also precisely controls the most critical parameter in the Camera, the vidicon focus current. This current is determined by the voltage across R47, which is in turn established by the zener voltage projected through the offsetting emitter-base diodes of Q15 and Q14.

The horizontal multivibrator, Q3 and Q4, generates the basic horizontal system blanking width (adjustable by R11). It may be triggered by any of three sources: (1) the internal crystal oscillator, Q1 and Q2, for use in stabilized random systems; (2) the optional sync generator for use in interlaced systems; and (3) external drive from an outside source. In the latter mode, the Camera may be driven by an external drive source, such as standard broadcast generators (EIA Standard RS-170).

Selection of the desired source is made by clipping a jumper lead to the appropriate pin. See Fig. 7 for instructions and pin marking.

Q3 also drives the horizontal sweep switch, Q5. In the resonant sweep driver used, C8 is the flyback capacitor, CR6 is the damper diode, and the combination of CR7 and C10 provides an offset voltage to minimize undesirable transients during the commutation of current between the switch and the damper. The flyback voltage generated in this stage is used to turn on Q9, which generates a vidicon blanking signal applied to the vidicon cathode through Q10. Q10 has a dual function, since it acts as a sweep failure protector by automatically turning on in the absence of the flyback pulse. The flyback pulse is also used to control Q6 which, in turn, supplies the sync and clamp pulses.

Refer to Fig. 8 for the relationships of the leading and lagging edges of the important timing waveforms in both horizontal and vertical axes.

It should be noted in Fig. 8 that the horizontal system blanking pulse is wider than the sweep flyback. This prevents the appearance of vidicon discharge and other transients near the edges of the raster.

In the vertical axis, the multivibrator, Q20 and Q21, generates the basic vertical system blanking width (adjustable by R64). As in the horizontal case, the vertical MV may be triggered from any of three sources: (1) the internal 60-hertz line, via amplifier Q19, for use in random systems; (2) by the optional sync generator for use in interlaced systems; and (3) external drive from other sources for use as a driven Camera. It should be noted that in both the horizontal and vertical cases, the external drive signal width is not critical, since only the leading edge is utilized.

The output of Q21 drives a second monostable multivibrator, Q23 and Q24, delayed by integrator R62-C26 and amplifier Q22. This delay prevents the white vidicon discharge from appearing at the bottom of the raster. This short multivibrator supplies a gate to the vertical sweep generator, Q25, and also determines the width of the vertical sync pulse (approximately 200 microseconds). As a result of the narrow sync pulse, a long back porch exists, which allows the monitor horizontal AFC to fully recover before the end of system blanking.

Q25, Q26, and Q27 constitute the vertical sweep generator. The resulting linear sweep is fed into feedback amplifier Q28 and Q29 to the vertical yoke. A top linearity control is not necessary here because of the high-gain feedback amplifier. Vertical sweep failure protection consists of two separate mechanisms. In case of a lack of vertical drive, the multivibrator, Q23 and Q24, has no output. As in the Q10 horizontal case, Q11 automatically turns on in the absence of an input signal from Q23 and the vidicon cathode becomes blanked. If there is a failure in the sweep generator or amplifier, the flyback waveform at the collector of Q29 diminishes or disappears. As a result, Q13 is turned on for a shorter period or not at all. Capacitors C18, C19, and C20 are then no longer able to maintain a negative charge, and Q12 is turned on through R44. This grounds the collector of Q12, killing the signal on the collector of Q9 and allowing Q10 to turn on. The two mechanisms insure that beam blanking will occur in the shortest possible time regardless of the location of the failure.

VIDEO BOARD

Refer to Figs. 9, 10, and 11.

The video board contains the full video chain, the sync and blanking mixers, the auto-target circuitry, and the simple shunt-regulated, medium-voltage supplies (+68 volts and -139 volts).

The vidicon target output is fed through a prepeaking network into the preamplifier. The video preamplifier, Q1, is a high performance junction field-effect transistor chosen for its low noise characteristics. The output of this gain stage is fed through emitter follower Q2 to the peaker, Q3. This stage is bypassed in the emitter to increase the gain in the high-frequency area to compensate for the fall-off due to the vidicon target capacity. A jumper/pin jack selection is available at this stage. Either a flat 10-Hz bandwidth or a bandwidth peaked at 400 lines is available. The peaked selection improves picture quality in bandwidth limited applications such as video tape. The signal is then fed through another follower Q4, to the gain control, R19, and is then amplified by the feedback pair, Q6 and Q7. The gain of this pair may be varied by changing the effective value of R28. This is done automatically by Q5, whose source-to-drain resistance is reduced when its gate voltage increases positively toward zero. Effectively, the gain of the video chain automatically increases when the light level decreases and the target voltage controlling Q5 increases. The output of Q7 is key-clamped by Q8 and then goes through emitter follower Q9 to another feedback pair, Q10 and Q11. This pair has enough gain to bring the video voltage swing up to four or five volts. The relatively high amplitude is necessary for proper performance of the black level clamp. The video polarity at the output of Q11 is black positive, and the blackest part of the signal causes CR2 to conduct at the setup level. This black level will be maintained despite those effects

which normally cause it to shift, namely, vidicon target voltage and faceplate temperature. In order to prevent the diode from clamping on the dark current level, which is more positive than the black portion of the video, the periods of vidicon blanking are forced into a white direction by the inverted composite vidicon blanking signals from Q19. The video is thereafter d-c coupled to the output. System blanking is inserted at the output of amplifier Q13 by Q20 and Q21. Gamma modification may optionally be inserted at this point by a jumper. The gamma network consists of CR3 and CR5 along with their associated resistors. Q14 and Q15 are emitter followers which drive the 75-ohm video output. The output circuit is protected and will not be damaged if the video output is shorted to ground.

The sync signal is inserted by Q22 and Q23 at the output point. The normal video output level as designated by EIA Standard RS-330 is 0.7 volt peak-to-peak. If, as a result of small high-intensity points in the scene, the video level tends to exceed this value, these white signals will be clipped at 1.5 volts by the white clipper, CR13 and CR14.

The video output level is sampled at the output of Q14 to feed the auto-target amplifier, Q18. The amplifier output is peak-to-peak detected by CR10 and CR11 and fed as a d-c level through Q17 to Q16. As the signal level tends to increase, Q16 is turned on and the resultant target voltage is reduced. R62 may be adjusted so that the output swing is fixed at any level between 0.5 and one volt. The target voltage may be varied in this automatic fashion from an effective value of 0 to 85 volts. As the scene brightness reduces and the target goes up, the video gain increases through the action of Q5. The crossover point where the video gain begins to increase as the target goes up is adjustable by R21. The automatic video gain prevents edge flare and vidicon lag caused by high target voltages. It also prevents the application of high target voltages when the lens is capped, thus increasing the life of the vidicon.

When it is desirable to feed a train of sync signals from an external source into the Camera, transistor Q22 is removed and inserted into the Q24 socket. The external sync train is then inverted by Q24 and mixed (by an appropriate jumper selection) through Q23 into the video output.

The +68 volt supply (target voltage supply) is shunt regulated by zener CR8, and the -139 volt supply (beam bias supply) is shunt regulated by neon regulator VR1.

INTERCONNECTION BOARD

Refer to Figs. 12, 13, and 14.

The interconnection board serves to connect the two main boards by printed wiring and in addition contains the vidicon high-voltage supply and the vidicon element bypass capacitors.

The high-voltage supply is rectified by 1CR1 and filtered by 1C4 and 1C5. The output is then fed into shunt regulators 1VR1, 1VR2, and 1VR3. These long-life neon regulators are much superior to zener diodes in temperature stability characteristics. As a result, the electrostatic focus voltage derived from this regulator is highly stable.

Since 1C4 and 1C5 are in series, both should be replaced if there is a failure of either unit.

SYNC GENERATOR

Refer to Figs. 2, 3, and 4.

The accessory sync generator produces a horizontal drive pulse of 15,750 kHz and a vertical drive pulse of 60Hz. Since the 60-Hz pulse is a result of division from the horizontal frequency, the two are synchronous, and an interlaced scan is produced by the driven Camera.

The generator is composed of a 31.5-kHz astable multivibrator, a group of integrated-circuit bistable multivibrators, circuitry to keep the 60-Hz pulse phase-locked to the line voltage, and a five-volt d-c power supply.

The astable clock (Q1 and Q2) frequency is controlled by the d-c level of its base return voltage. The output of this clock is buffered by Q3 and then drives the flip-flop, Z11, which provides the 15.75-kHz horizontal drive pulse. The buffer also triggers Z1, the first of the string of dividers, which in turn triggers Z2, and so on down through Z3 through Z10. This chain divides the input signal by 525, and the last divider, Z10, produces the 60-Hz vertical drive signal. Z12 and Z13 are gates that sample the state of each divider and then reset the whole group when the 525 count is complete.

A sample of the 60-Hz sine wave is fed to the emitter of Q5 through Q12. The base of Q5 is turned on by a narrow positive pulse derived from the 60-Hz divider. The collector of Q5 is shifted either more positively or more negatively, depending upon when the base pulse occurs relative to the zero crossover of the 60-Hz signal on the emitter. The collector voltage is integrated by C8, R9, and C7 and sent through emitter follower Q4 to control the clock phase. R7 manually adjusts the clock frequency and is set to the middle of the lock-in range.

The 6.3-volt a-c vidicon filament winding is used to generate a five-volt d-c supply to efficiently power the integrated circuits. The supply is well filtered by C1, R1, and C2. Although the supply voltage may vary ± 10% in accordance with the line voltage, the performance of the integrated circuits does not deteriorate. The total power consumed by the generator is slightly less than one watt.

A group of jumpers are available on the generator to allow it to run at other than the standard 525-line rate. Jumper locations may be determined by reference to the table on the Sync Generator Board Schematic Diagram, Fig. 4. The values of capacitors C5 and C6 in the clock may also have to be changed for some of the higher rates. The narrow vertical pulse fed into the base of Q5 normally comes from the short multivibrator of the Camera. At the 525-line rate only, this pulse may be taken from the Z10 divider output of the sync generator.

VIDICON TUBE

Refer to the pertinent vidicon tube bulletin and to EBI-3781, Fundamentals of the Vidicon Tube and Transistor Characteristics, included as an insert in this book.

MAINTENANCE

GENERAL

To assure continuously satisfactory operation of the Camera, the first requirement is to keep it as clean and dry as possible. Always leave the cover on the Camera for best protection. Allow for adequate ventilation around the Camera case.

PARTS REPLACEMENT

The Parts List for the Camera and its boards is located in the back of this book.

If a component must be replaced, obtain its description from the Parts List and the part from a local parts distributor. When a special part not available from a local distributor must be replaced, order it by GE Drawing number (found in the Parts List), addressing the order to the General Electric Company, Replacement Parts, Visual Communication Products Department, Electronics Park, Syracuse, New York 13201.

COMPONENT BOARD SERVICE NOTES

The following steps will be of aid when replacing components on the boards. Use only a 25- or 35-watt soldering iron to service the equipment since excessive heat can damage wiring and components.

CAUTION

DO NOT USE A LARGE SOLDERING IRON TO SERVICE A BOARD.
DO NOT REMOVE A TRANSISTOR WHILE POWER IS APPLIED TO THE BOARD: TO DO SO MAY PERMANENTLY DAMAGE THE TRANSISTOR.

1. Grip the component to be removed at one end with long-nose pliers, then apply a narrow-tip soldering iron to the component lead, barely touching the board wiring. While the solder joint melts, pull the lead lightly with the pliers until it can be pulled free of the board. Free the other lead in the same way.

2. When a component is removed, replace it with a new component of the same value. When installing the new component, observe the length and dress of the leads on the old component, then cut and bend the leads of the new component in the same way.

3. Place the leads in the holes. If residual solder prevents a lead from entering the hole, very gently ream out the solder with a sharply pointed, square awl. Then place the leads into the holes so that component is held in place by friction or slight spring tension of its leads.

4. Using high-grade electrical solder, apply the soldering iron tip, then apply the solder to the junction of the hole, so that a very small amount of solder flows around the lead and into the hole, bonding the lead to the board.

5. Examine the joint carefully. A good solder joint should withstand a light pull by the fingers. Clear away any loose solder, making sure that no scraps fall where they might cause a short.

Although the circuit boards are designed to be extremely rugged when mounted as an intergral part of the Camera, great care must be exercised when handling them alone. Parts may be damaged, for example, by placing a board component-side down and inadvertently placing another object on the board.

CAUTION

IN ORDER TO INSURE PROPER CAMERA OPERATION, FIRMLY TIGHTEN ALL CIRCUIT BOARD CAPTIVE MOUNTING SCREWS WHEN A BOARD IS REPLACED.

TROUBLESHOOTING

The first step in locating trouble is to isolate it to a particular section of the Camera.

A list of the more common difficulties and faults that may arise in the Camera is given below.

Trouble	Remedy
Low contrast picture without excessive noise (snow).	Advance the monitor CONTRAST control. Advance the TARGET control. Open the lens iris.
Low contrast picture with noise (snow).	Open the lens iris. Provide more scene illumination.
Lack of detail.	Clean the front of the vidicon tube and the Camera lens. Focus the electrical FOCUS control. Focus optically. Turn down the Camera TARGET and the monitor CONTRAST controls (picture was overloading the monitor). Turn down the BEAM control.
Camera will not operate (pilot light does not light).	Check the $\frac{1}{4}$-ampere fuse on the rear panel of the Camera.
Pilot light lights, but there is no picture output.	Advance the BEAM control setting. Advance the TARGET setting.

Trouble	Remedy
Picture will not lock horizontally.	Check the oscillator frequency. Check the coaxial cable from the video output to the monitor for an open or short.
Picture blooms.	Make certain that the video cable is terminated in 75 ohms at the monitor.

TROUBLESHOOTING TRANSISTOR CIRCUITS

The troubleshooting techniques described in EBI-3781 are applicable to this Camera.

Refer also to the waveforms, Figs. 15 through 25.

TESTING TRANSISTORS

Refer to EBI-3781.

LENSES

Exercise care when cleaning lenses since they are easily scratched. Use the following procedure for cleaning:

1. Slightly moisten a lens cleaning tissue, or other similar material, with isopropyl alcohol and wipe the lens, using a light pressure.

2. Use a soft camel hair brush when the lenses are subject to dust only. Tape the metal ferrule on the brush to prevent accidental scratching of the lens.

CAMERA AND SWEEP CHASSIS ADJUSTMENT

NOTE

Set the BEAM control fully counterclockwise and allow the Camera a five-minute warm-up before attempting to adjust the sweep circuits.

1. Position the RETMA resolution chart, located in the back of this book, on a wall or other convenient support facing the Camera. The center of the chart must be at the height of the lens, and the chart should have the plus sign (+) at the top and the title at the bottom.

2. Reduce the horizontal and vertical size controls on the display monitor until the entire monitor raster, including the corners, is visible.

3. Overscan the vidicon tube by turning the HOR SIZE and VERT SIZE controls on the power-sweep board counterclockwise until the complete circular image of the vidicon photoconductor is visible on the monitor screen.

4. Because some vidicons are now manufactured with the faceplate masked off to indicate the proper area to be scanned, the following steps will insure proper scan of the required $\frac{1}{2}$ x 3/8 inch area of the vidicon photoconductor.

Position the RETMA resolution chart in front of the Camera at the distance that corresponds to the lens being used. Refer to the Chart-To-Camera Distance Table, below. Adjust the sweep so that the entire chart is just displayed on the monitor. Disregard the black border around the chart. Refer to Fig. 26.

CHART-TO-CAMERA DISTANCE TABLE

Lens	Distance
15 mm	$10\frac{1}{2}$ inches
25 mm	16 inches
50 mm	33 inches
75 mm	$49\frac{1}{2}$ inches
100 mm	$65\frac{1}{2}$ inches

All measurements are from the resolution chart to the bottom front edge of the Camera.

It may be necessary to redure the TARGET voltage control setting so that the edge of the photoconductor is clearly defined. Do not move the chart or the Camera.

5. Adjust the height (VERT SIZE), vertical centering (VERT CTR), width (HOR SIZE), and horizontal centering (HOR CTR) controls on the power-sweep board so that the chart just fills the monitor raster. Note the small white wedge-shaped indicators on the edges of the raster. When these arrows touch the edges of the raster, the size and centering controls are properly set.

6. Expand the monitor presentation back to its normal size.

FREQUENCY RESPONSE ALIGNMENT

To properly align the preamplifier of a high-gain vidicon strip, it has been found necessary to employ a special sweep probe. Refer to Fig. 27 for a diagram of the sweep probe Alignicon circuit. It is important to note that the probe must be constructed so that it will be completely shielded by metal and that all leads are kept as short as feasible. The output touches the vidicon target contact through the lens opening at the front of the Camera.

In addition to the sweep probe, a completely shielded detector probe, also shown in Fig. 27, is required. It is recommended that the detector probe be constructed in a small aluminum or copper box or tube, with all the components

inside the box, and that UHF-type coaxial connectors be used for input and output terminals. A detector probe is not essential if an oscilloscope is available that has a bandwidth of 15 mHz or more, in which case the Camera must be terminated (see Fig. 27).

Follow the procedure given below to align the frequency response of the video amplifier.

1. WITH ALL POWER REMOVED FROM THE CAMERA (POWER CORD DISCONNECTED FROM THE POWER OUTLET), remove the vidicon, using the procedure outlined later in this section.

2. Connect the test equipment to the Camera as shown in Fig. 27.

3. Apply a-c power to the Camera, set the video GAIN control, 3R19, to the 12 o'clock position, and observe the response on the oscilloscope. If no response is seen, check for connection between the Alignicon and the target contact.

4. The input sensitivity of the oscilloscope should remain at a high setting and the sweep generator output reduced to prevent overloading of the Camera amplifier. Adjust the input amplitude to get an output amplitude of 0.7 volt.

5. Adjust 3C25 for the flattest response out to 10 mHz.

6. Remove a-c power from the Camera and the alignment equipment.

7. Replace the vidicon, using the procedure given below.

VIDICON TUBE REMOVAL

WARNING

BEFORE REMOVING A TUBE, BE SURE THAT ALL POWER IS OFF BY REMOVING THE POWER CORD FROM THE POWER SOURCE.

1. Check to see that the power cable has been disconnected from the power source.

2. Remove the Camera cover by loosening the four captive screws on the Camera cover bottom and lifting the cover, exposing the interior.

3. Remove the Camera lens.

4. Using the special spanner wrench (PL-7167210G3), unscrew the lens holder, using the two small holes in the holder to engage the wrench.

5. Unplug the vidicon socket.

6. Gently move the vidicon forward (from the rear) until about one-half inch of the tube protrudes from the front of the Camera.

7. Carefully extract the vidicon from the front of the Camera.

VIDICON TUBE REPLACEMENT

WARNING

BEFORE REPLACING A VIDICON, BE SURE THAT ALL POWER IS OFF.

In general, replacement of the vidicon is the reverse of the procedure for removal.

1. Clean the vidicon faceplate.

2. Insert the tube through the lens opening into the yoke.

3. Plug the socket onto the tube, orienting the tube so that the index (short) pin of the tube is in the 9 o'clock position as viewed from the rear of the Camera.

4. If necessary, clean the faceplate of the vidicon.

5. Replace the lens holder and the lens.

6. Replace the Camera cover.

CIRCUIT BOARD REMOVAL

1. REMOVE ALL POWER FROM THE CAMERA.

2. Loosen the four captive screws on the Camera cover bottom and lift the cover off, exposing the two main circuit boards, power-sweep and video, and the sync generator if it has been installed.

3. Remove the five screws that hold each board (or four screws in the case of the sync generator board). When removing the video board, disconnect the target and video output pins. Disconnect the board by unplugging it at the edge connector, then remove it.

NOTE

Removal of the four screws on the rear panel and the two screws on the bottom rear of the Camera allows the panel to drop down and offer access to the control potentiometers, power switch, and fuse.

PARTS LIST

Symbol	Description	GE Drawing
	CAMERA ASSEMBLY PL-7699917G1	
	INDUCTORS	
L1	Yoke, 1" vidicon. Chuo Musen Co. Ltd., Tokyo, Japan, Model #KV9-D.	D-7699887-P1
L2	RF coil; 33 uh ± 10%, max d-c resistance 3.8 ohms.	B-7498929-P85
	RESISTOR	
R1	Composition; 10,000 ohms ± 5%, ¼ w.	C-3R152-P103J
	TRANSFORMER	
T1	Transformer. Pri: 117 v a-c ± 10%, 50/60 hertz; sec #1: 610 v d-c, 5 ma; sec #2: 25 v d-c, 400 ma; sec #3: 6.3 v a-c, 0.21/0.72 amp.	C-7799604-P1
	INTERCONNECTION BOARD PL-7699910G1	
	CAPACITORS	
1C1	Mylar, metalized; 0.022 mfd ± 20%, 600 v d-c w.	B-7493817-P16
1C2	Ceramic, Hi-K disk. 0.01 mfd +100% -0%, 500 v d-c w.	C-7774750-P13
1C3	Metalized mylar; 0.022 mfd ± 20%, 600 v d-c w. Good-All Type X663F.	B-7493817-P16
1C4 and 1C5	Electrolytic; 5.0 mfd +50% -10%, 450 v d-c w.	C-7774786-P49

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED)	
1C6	Ceramic, Hi-K disk; 0.01 mfd +80% -20%, 450 v d-c w. Centralab Type DA-048.	B-7488160-P1
1C7 and 1C8	Electrolytic; 500 mfd +100% -10%, 35 v d-c w. General Instrument Corp. Type 977-2043.	C-7775849-P176
1C9	Polyester; 0.01 mfd ± 10%, 50 v.	H604AC-P3102
	RECTIFIER	
1CR1	Silicon; 200 PIV d-c. Atlantic Semiconductor Corp. Type 25D20.	B-7499882-P2
	CONNECTORS	
1J1 and 1J2	30 contacts, 15 per side. Winchester Electronic Cat. #8BDJ15D0.	B-7380168-P2
	TRANSISTOR	
Q1	Bendix Type B-5031.	A-7164451-P333
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
1R1	1000 ohms.	C-3R152-P102J
1R2	0.10 megohm, $\frac{1}{2}$ w.	C-3R77-P104J
1R3	Precision; 1.0 megohm ± 1%, $\frac{1}{4}$ w.	C-3R166-P1004
1R4	0.39 megohm.	C-3R152-P394J
1R5	1.5 megohm.	C-3R152-P155J
1R6	47,000 ohms.	C-3R152-P473J
1R7	10,000 ohms.	C-3R152-P103J

Symbol	Description	GE Drawing
	GLOW LAMPS	
1VR1 thru 1VR3	Voltage regulator. Signalite Cat. #Z139R1.9.	B-7380554-P5
	TUBE SOCKET	
1XV1	Mica filled phenolic, for small-button ditetrar, 8 pin base tubes. Cinch Cat. #54A18088 or Chuo Musen (QQQ) Type TV-808.	A-7143125-P1
	REAR PANEL PL-7799610G1,2 (Model 4TE26A1 only.)	
	CAPACITORS	
2C1 and 2C2	Ceramic; 0.01 mfd ± 20%, 1000 v d-c w.	B-7399141-P1
	FUSE	
2F1	Slow blow; $\frac{1}{4}$ amp at 250 v. Bussman Type MDV.	B-7498196-P4
	INDICATOR LIGHT	
2I1	Part of 2S1.	
	CONNECTORS	
2J1	Bulkhead receptacle. MIL Type UG-1094/U.	C-7776570-P17
2J2 thru 2J4	Bulkhead receptacles. MIL Type UG-1094/U. (PL-7799601G2 only.)	C-7776570-P17
2P1	Power cord with plug, General Insulated Type Type G1-5B or Royal Type MP-11. (PL-7799610G1 only.)	C-7777121-P2
2P6	Power cord with plug, General Insulated Type G1-5B or Royal Type MP-11. (PL-7799610G2 only.)	C-7777121-P2

Symbol	Description	GE Drawing
	RESISTORS	
2R1 thru 2R3	Potentiometers, carbon film; 1.0 megohm ± 30%, 0.5 w, linear taper.	C-7799606-P208
2R4	Potentiometer, carbon composition; 2500 ohms ± 20%, $\frac{1}{2}$ w. linear taper. Allen Bradley Type G.	B-7380199-P5
2R5	Composition; 2.7 megohm ± 5%, $\frac{1}{4}$ w.	C-3R152-P275J
2R6	Composition; 4700 ohms ± 5%, $\frac{1}{4}$ w.	C-3R152-P472J
2R7	Part of 2S1.	
	SWITCHES	
2S1	Slide switch, illuminated; neon lamp, red color. UID Electronics Corp. Cat.# LSW-322-N-30KR.	B-7399119-P11
2S2	Toggle type, miniature; spdt. Alco Electronics Inc. Part #MST-115D.	A-7171932-P1
	REAR PANEL PL-7799611G2 (Model 4TE26B1 only.)	
	CAPACITORS	
2C1 and 2C2	Ceramic; 0.01 mfd ± 20%, 1000 v d-c w.	B-7399141-P1
	FUSE	
2F1	Slow blow; $\frac{1}{4}$ amp at 250 v. Bussman Type MDV.	B-7498196-P4
	INDICATOR LIGHT	
2I1	Part of 2S1.	
	CONNECTORS	
2J1 thru 2J4	Bulkhead receptacle. MIL Type UG-1094/U.	C-7776570-P17

Symbol	Description	GE Drawing
	CONNECTORS (CONTINUED)	
2J5	Male. Amphenol Cat. #67-02E14-12P.	B-7493723-P68
2P6	Power cord with plug, General Insulated Type Gl-5B or Royal Type MP-11.	C-7777121-P2
	RESISTORS	
2R6	Composition; 2200 ohms ± 5%, $\frac{1}{4}$ w.	C-3R152-P222J
2R7	Part of 2S1.	
	SWITCH	
2S1	Slide switch, illuminated; neon lamp, red color. UID Electronics Corp. Cat. #LSW-322-N-30KR.	B-7399119-P11
	VIDEO BOARD PL-7699909G1	
	CAPACITORS	
3C1	Polyester; 0.47 mfd ± 10%, 100 v.	H605AC-P3472
3C2 and 3C3	Polyester; 0.01 mfd ± 10%, 100 v.	H605AC-P3102
3C4	Electrolytic; 10 mfd +75% -10%, 25 v d-c w. General Instrument Cat. #974-18.	B-7489483-P42
3C5	Silver mica, epoxy dipped; 43 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P18
3C6	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
3C7	Electrolytic; 200 mfd +75% -10%, 35 v d-c w. Sprague Cat. #30D116A1.	B-7489483-P15
3C8	Electrolytic; 100 mfd +75% -10%, 12 v d-c w. General Instrument Cat. #974-10.	B-7489483-P45
3C9 and 3C10	Electrolytic; 10 mfd +75% -10%, 25 v d-c w. General Instrument Cat. #974-18.	B-7489483-P42

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED)	
3C11	Silver mica, epoxy dipped; 680 pf ± 5%, 300 v d-c w. Electromotive Type DM15.	B-7496931-P46
3C12	Variable, mica; 380 pf max capacitance at 3 turns open, 50 pf min capacitance at 1 3/4 in. lbs torque. Elmenco Type 46.	B-7496838-P9
3C13	Tantalum type; 100 mfd ± 20%, 20 v d-c w. Sprague Cat. #196D107X0020GT.	B-7399123-P2
3C14 and 3C15	Electrolytic; 10 mfd +75% -10%, 25 v d-c w. General Instrument Cat. #974-18.	B-7489483-P42
3C16	Electrolytic; 50 mfd +75% -10%, 6 v d-c w. General Instrument Cat. #974-71.	B-7489483-P50
3C17	Polyester; 0.047 mfd ± 10%, 50 v.	H604AC-P3472
3C18	Electrolytic; 100 mfd + 75% -10%, 12 v d-c w. General Instrument Cat. #974-10.	B-7489483-P45
3C19	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
3C20	Electrolytic; 100 mfd +75% -10%, 25 v d-c w. Sprague Cat. #30D107G025DD2.	B-7489483-P37
3C21	Electrolytic; 100 mfd +75% -10%, 12 v d-c w. General Instrument Cat. #974-10.	B-7489483-P45
3C22	Mylar, dielectric; 0.47 mfd ± 5%, 50 v d-c w.	B-7496934-P210
3C23 and 3C24	Electrolytic; 10 mfd +75% -10%, 25 v d-c w. General Instrument Cat. #974-18.	B-7489483-P42
3C25	Variable, ceramic; 3 to 12 pf +0% -100% min, +50% -0% max. Erie Series 557, Dielectric Code A.	B-7493393-P103
3C27 and 3C28	Electrolytic; 3.0 mfd +75% -10%, 300 v d-c w. General Instrument Cat. #977-15.	B-7489483-P40
3C29	Polyester; 0.022 mfd ± 10%, 50 v.	H604AC-P3222
3C30	Polyester; 0.047 mfd ± 10%, 50 v.	H604AC-P3472

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED)	
3C31	Silver mica, epoxy dipped; 100 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P27
3C33 and 3C34	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
3C35	Electrolytic; 5.0 mfd +75% -10%, 50 v d-c w. Sprague Cat. #30D193A1.	B-7489483-P33
3C36	Silver mica, epoxy dipped; 56 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P21
3C37	Electrolytic; 10 mfd +75% -10%, 25 v d-c w. General Instrument Cat. #974-18.	B-7489483-P42
3C35	Silver mica, epoxy dipped; 220 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P35
3C39	Polyester; 0.047 mfd ± 10%, 50 v.	H604AC-P3472
3C40	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
3C41	Polyester; 0.010 mfd ± 10%, 50 v.	H604AC-P3102
3C42	Polyester; 0.047 mfd ± 10%, 50 v.	H604AC-P3472
	RECTIFIERS	
3CR1	Zener diode; 5.3 v min to 5.9 v max. GE Type 5.6Z.	B-7499649-P3
3CR2 thru 3CR5	GE Type 1N4454.	A-7164424-P104
3CR7	Silicon; 600 PIV. GE Type A13M2/A14M/1N5061.	B-7499220-P4
3CR8	Zener diode; 68 v ± 10%, 1 w. JEDEC Type 1N4760, Motorola Type 1M68ZS.	A-7172767-P33
3CR9	Silicon; 600 PIV. GE Types A13M2/A14M/1N5061.	B-7499220-P4
3CR10 thru 3CR14	GE Type 1N4454.	A-7164424-P104

Symbol	Description	GE Drawing
	INDUCTORS	
3L1	RF coil; 15 uh ± 10%, d-c resistance 1.2 ohms max. Jeffers Cat. #4421-9.	B-7498929-P13
3L2	RF coil; 4.7 uh ± 10%, d-c resistance 0.22 ohm max. Jeffers Cat. #4421-3.	B-7498929-P12
3L3	RF coil; 56 uh ± 5%, d-c resistance 3.1 ohms max. Jeffers Cat. #1315-6J.	B-7498929-P81
3L4	RF coil; 220 uh ± 10%, d-c resistance 7.2 ohms max. Jeffers Cat. #1315-20.	B-7498929-P75
	TRANSISTORS	
3Q1	TI Type TIS-88/2N5245.	A-7164451-P257
3Q2	Fairchild Type 2N4916.	A-7164451-P344
3Q3	RCA Type 2N5181.	A-7164451-P334
3Q4	Fairchild Type 2N4916.	A-7164451-P344
3Q5	Amelco, Fairchild or Continental Devices Type 2N5163.	A-7164451-P345
3Q6	GE Type 2N3663.	A-7164451-P211
3Q7	Fairchild Type 2N4916.	A-7164451-P344
3Q8	GE or Sprague Type 2N4256.	A-7164451-P343
3Q9 and 3Q10	GE Type 2N3663.	A-7164451-P211
3Q11 thru 3Q14	Fairchild Type 2N4916.	A-7164451-P344
3Q15	GE or Sprague Type 2N3403.	A-7164451-P335
3Q16	GE Type 2N5176.	A-7164451-P332
3Q17	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
3Q18 and 3Q19	GE Type 2N3415.	A-7164451-P213

Symbol	Description	GE Drawing
	TRANSISTORS (CONTINUED)	
3Q20	GE Type 2N3663.	A-7164451-P211
3Q21	GE or Sprague Type 2N4256.	A-7164451-P343
3Q22 and 3Q23	Fairchild Type 2N3646.	A-7164451-P195
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
3R1 and 3R2	10 megohm.	C-3R152-P106J
3R3	0.10 megohm.	C-3R152-P104J
3R4	0.27 megohm.	C-3R152-P274J
3R5	470 ohms.	C-3R152-P471J
3R6	3300 ohms.	C-3R152-P332J
3R7	6800 ohms.	C-3R152-P682J
3R8	1200 ohms.	C-3R152-P122J
3R9	100 ohms.	C-3R152-P101J
3R10	10,000 ohms.	C-3R152-P103J
3R11	3300 ohms.	C-3R152-P332J
3R12	330 ohms.	C-3R152-P331J
3R13	1500 ohms.	C-3R152-P152J
3R14	10 ohms.	C-3R152-P100J
3R15	3300 ohms,	C-3R152-P332J
3R16	1000 ohms.	C-3R152-P102J
3R17	2700 ohms.	C-3R152-P272J
3R18	3300 ohms.	C-3R152-P332J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
3R19	Potentiometer, carbon composition; 1000 ohms ± 30%, 0.25 w.	B-7399124-P2
3R20	4700 ohms.	C-3R152-P472J
3R21	Potentiometer, carbon composition; 1.0 megohm ± 30%, 0.25 w.	B-7399124-P11
3R22	750 ohms.	C-3R152-P751J
3R23 and 3R24	1500 ohms.	C-3R152-P152J
3R25	0.33 megohm.	C-3R152-P334J
3R26	2000 ohms.	C-3R152-P202J
3R27	3300 ohms.	C-3R152-P332J
3R28	150 ohms.	C-3R152-P151J
3R29	1000 ohms.	C-3R152-P102J
3R30	27,000 ohms.	C-3R152-P273J
3R31	15,000 ohms.	C-3R152-P153J
3R32	1000 ohms.	C-3R152-P102J
3R33	7500 ohms.	C-3R152-P752J
3R34	3300 ohms.	C-3R152-P332J
3R35	360 ohms.	C-3R152-P361J
3R36	3300 ohms.	C-3R152-P332J
3R37 and 3R38	2200 ohms.	C-3R152-P222J
3R39	680 ohms.	C-3R152-P681J
3R40	1.0 megohm.	C-3R152-P105J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
3R41	7500 ohms.	C-3R152-P752J
3R42	2000 ohms.	C-3R152-P202J
3R43	100 ohms.	C-3R152-P101J
3R44	10,000 ohms.	C-3R152-P103J
3R45	1500 ohms.	C-3R152-P152J
3R46	200 ohms.	C-3R152-P201J
3R47	10,000 ohms.	C-3R152-P103J
3R48	1000 ohms.	C-3R152-P102J
3R49	10,000 ohms.	C-3R152-P103J
3R50	100 ohms.	C-3R152-P101J
3R51	910 ohms, $\frac{1}{2}$ w.	C-3R77-P911J
3R52	10,000 ohms.	C-3R152-P103J
3R53	68 ohms.	C-3R152-P680J
3R54	75,000 ohms.	C-3R152-P753J
3R55	33,000 ohms, $\frac{1}{2}$ w.	C-3R77-P333J
3R56 and 3R57	0.10 megohm.	C-3R152-P104J
3R58	2200 ohms.	C-3R152-P222J
3R59	4700 ohms.	C-3R152-P472J
3R60	22,000 ohms.	C-3R152-P223J
3R61	0.30 megohm.	C-3R152-P304J
3R62	Potentiometer, carbon composition; 10,000 ohms ± 30%, 0.25 w.	B-7399124-P6
3R63	4700 ohms.	C-3R152-P472J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
3R64	820 ohms.	C-3R152-P821J
3R67	1500 ohms.	C-3R152-P152J
3R68	22,000 ohms.	C-3R152-P223J
3R69	10,000 ohms.	C-3R152-P103J
3R70	4700 ohms.	C-3R152-P472J
3R71	2700 ohms.	C-3R152-P272J
3R72	1500 ohms.	C-3R152-P152J
3R73	0.15 megohm.	C-3R152-P154J
3R74	4700 ohms.	C-3R152-P472J
3R75	0.15 megohms.	C-3R152-P154J
3R76	470 ohms.	C-3R152-P471J
3R77	2400 ohms.	C-3R152-P242J
3R78	10,000 ohms.	C-3R152-P103J
3R79	1500 ohms.	C-3R152-P152J
3R80	47,000 ohms.	C-3R152-P473J
3R81	2000 ohms.	C-3R152-P202J
3R82	47,000 ohms.	C-3R152-P473J
3R83	2200 ohms.	C-3R152-P222J
3R85	3300 ohms.	C-3R152-P332J
3R86	0.47 megohm.	C-3R152-P474J
3R87	1000 ohms.	C-3R152-P102J
3R88	1.0 megohm.	C-3R152-P105J
3R89	27,000 ohms.	C-3R152-P273J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, ½ w, unless otherwise specified.)	
3R90	0.33 megohm.	C-3R152-P334J
3R91	470 ohms.	C-3R152-P471J
3R92	10,000 ohms.	C-3R152-P103J
	GLOW LAMP	
3VR1	Voltage regulator. Signalite Cat.#Z139R1.9.	B-7380554-P5
	TRANSISTOR SOCKETS	
3XQ1	Industrial Electronic Hardware Corp. Part #MPT4003-3.	C-7799601-P1
3XQ5	Industrial Electronic Hardware Corp. Part #MPT4003-3.	C-7799601-P1
3XQ8	Industrial Electronic Hardware Corp. Part #MPT4003-3.	C-7799601-P1
3XQ19	Industrial Electronic Hardware Corp. Part #MPT4003-3.	C-7799601-P1
3XQ22 thru 3XQ24	Industrial Electronic Hardware Corp. Part #MPT4003-3.	C-7799601-P1
	POWER-SWEEP BOARD PL-7699908G1	
	CAPACITORS (Electrolytic, +75% -10%, 25 v d-c w, unless otherwise specified.)	
4C1	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C2	Polyester; 0.0022 mfd ± 10%, 50 v.	H604AC-P2222
4C3	Ceramic, Hi-K disk, 0.001 mfd +100% -0%, 500 v d-c w.	C-7774750-P4

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, +75% -10%, 25 v d-c w, unless otherwise specified.)	
4C4	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C5	Silver mica, epoxy dipped; 300 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P38
4C6	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C7	10 mfd. General Instrument Cat. #974-18.	B-7489483-P42
4C8	Silver mica, epoxy dipped; 2200 pf ± 2%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P216
4C9	Electrolytic, solid tantalum type; 22 mfd ± 20%, 35 v d-c w. TI Type SCM226GP035C4, Sprague Type 150D226X0035R2.	B-7493471-P8
4C10	50 mfd, 6 v d-c w. General Instrument Cat. #974-71.	B-7489483-P50
4C11	Polyester; 0.010 mfd ± 10%, 50 v.	H604AC-P3102
4C13	200 mfd, 35 v d-c w. General Instrument Cat. #977-131.	B-7489483-P46
4C14	5.0 mfd, 50 v d-c w. Sprague Cat. #30D193A.	B-7489483-P33
4C15	10 mfd. General Instrument Cat. #974-18.	B-7489483-P42
4C16	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C17	Mylar, dielectric; 0.47 mfd ± 5%, 50 v d-c w.	B-7496934-P210
4C18 thru 4C21	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C22	Polyester; 0.047 mfd ± 10%, 100 v.	H605AC-P3472
4C23	Ceramic, Hi-K disk; 0.001 mfd +100% -0%, 500 v d-c w.	C-7774750-P4
4C24	10 mfd. General Instrument Cat. #974-18.	B-7489483-P42
4C25	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C26	Polyester; 0.010 mfd ± 10%, 50 v.	H604AC-P3102
4C27	Mylar, dielectric; 0.47 mfd ± 5%, 50 v d-c w.	B-7496934-P201

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electroltytic, +75% -10%, 25 v d-c w, unless otherwise specified.)	
4C28	10 mfd. General Instrument Cat. #974-18.	B-7489483-P42
4C29	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C31	Silver mica, epoxy dipped; 2200 pf ± 2%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P216
4C32	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
4C33	Metalized mylar; 1.0 mfd ± 10%, 100 v d-c w. Good-All Type X663F.	B-7493817-P14
4C34	Tantalum type; 100 mfd ± 20%, 20 v d-c w. Sprague Cat. #196D107X0020GJ.	B-7399123-P?
4C35	10 mfd. General Instrument Cat. #974-18.	B-7489483-P42
4C36	Polyester; 0.010 mfd ± 10%, 50 v.	H604AC-P3102
4C37	Polyester; 0.10 mfd ± 20%, 50 v.	H604AC-P4101
	RECTIFIERS	
4CR1 and 4CR2	GE Type 1N4454.	A-7164424-P104
4CR3	Silicon; 400 v, 1 amp, 1.5 u sec recovery. Motorola Type MR2272.	C-7782158-P1
4CR4 and 4CR5	GE Type 1N4454.	A-7164424-P104
4CR5	Motorola Type 1N4003.	A-7164424-P151
4CR7 thru 4CR9	GE Type 1N4454.	A-7164424-P104
4CR10 thru 4CR13	Motorola Type 1N4003.	A-7164424-P151

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, +75% -10%, 25 v d-c w, unless otherwise specified.)	
4CR14	Zener diode; 5.3 v min to 5.9 v max. GE Type 5.6Z.	B-7499649-P3
4CR17	TI Type 614C.	A-7164424-P6
4CR18 thru 4CR20	GE Type 1N4454.	A-7164424-P104
4CR21	Zener diode; 5.3 v min to 5.9 v max. GE Type 5.6Z.	B-7499649-P3
4CR22 and 4CR23	GE Type 1N4454.	A-7164424-P104
4CR24	Zener diode; 150 v ± 5%, 1 w. Power Components Type TZ13.	A-7172767-P147
4CR25 and 4CR26	Zener diodes; 5.3 v min to 5.9 v max. GE Type 5.6Z.	B-7499649-P3
	INDUCTORS	
4L1	Inductance 10,000 uh ± 10%, d-c resistance 75 ohms max. Aladdin Part #22-105.	B-7493492-P2
4L2	Inductance 0.75 mh ± 10%, d-c resistance 0.4 ohm ± 0.15 ohm. Penn-Trann Corp. Type 1216.	B-7499813-P2
4L3	Inductance 68,000 uh ± 10%, d-c resistance 115 ohms max. Aladdin Part. #83-685.	B-7493493-P5
	TRANSISTORS	
4Q1 thru 4Q3	GE Type 2N3415.	A-7164451-P213
4Q4	Fairchild Type 2N3646.	A-7164451-P195
4Q5	GE Type D28D10.	A-7164451-P331

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, +75% -10%, 25 v d-c w, unless otherwise specified.)	
4Q6	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
4Q7	Motorola Type 2N4918.	A-7164451-P295
4Q8	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
4Q9	GE Type 2N3415.	A-7164451-P213
4Q10 and 4Q11	Motorola Type MPS6518.	A-7164451-P243
4Q12 and 4Q13	GE Type 2N3415.	A-7164451-P213
4Q14	Motorola Type 2N4921.	A-7164451-P294
4Q15	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
4Q16 thru 4Q24	GE Type 2N3415.	A-7164451-P213
4Q25	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
4Q26 and 4Q27	GE Type 2N3415.	A-7164451-P213
4Q28	Raytheon or Fairchild Type 2N5138.	A-7164451-P342
4Q29	GE or Sprague Type 2N3403.	A-7164451-P335
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
4R1	68,000 ohms.	C-3R152-P683J
4R2	2200 ohms.	C-3R152-P222J
4R3	1000 ohms.	C-3R152-P102J
4R4	4700 ohms.	C-3R152-P472J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
4R5	0.51 megohm.	C-3R152-P514J
4R6	10,000 ohms.	C-3R152-P103J
4R7 and 4R8	2200 ohms.	C-3R152-P222J
4R9	10,000 ohms.	C-3R152-P103J
4R10	2200 ohms.	C-3R152-P222J
4R11	Potentiometer, carbon composition; 10,000 ohms ± 30%, 0.25 w.	B-7399124-P6
4R12	Precision; 47,500 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P4752
4R13	1000 ohms.	C-3R152-P102J
4R14	4700 ohms.	C-3R152-P472J
4R15	Potentiometer, wirewound; 1000 ohms ± 20%, 2 w.	B-7497351-P14
4R16	470 ohms, $\frac{1}{2}$ w.	C-3R77-P471J
4R17	0.22 megohm.	C-3R152-P224J
4R18	3000 ohms.	C-3R152-P302J
4R20	2200 ohms.	C-3R152-P222J
4R21	Potentiometer, wirewound; 5000 ohms ± 20%, 2 w.	B-7497351-P15
4R22	2200 ohms.	C-3R152-P222J
4R23 and 4R24	68,000 ohms.	C-3R152-P683J
4R25	470 ohms.	C-3R152-P471J
4R26	4700 ohms.	C-3R152-P472J
4R27	220 ohms.	C-3R152-P221J
4R28	68,000 ohms.	C-3R152-P683J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, ¼ w, unless otherwise specified.)	
4R29	1000 ohms.	C-3R152-P102J
4R30	10 ohms.	C-3R152-P100J
4R31	1000 ohms.	C-3R152-P102J
4R32	1500 ohms.	C-3R152-P152J
4R33	Precision; 6810 ohms ± 1%, ¼ w.	C-3R166-P6811
4R34	Precision; 6810 ohms ± 1%, ¼ w.	C-3R166-P6811
4R35	0.10 megohm.	C-3R152-P104J
4R36 and 4R37	10,000 ohms.	C-3R152-P103J
4R38	1000 ohms.	C-3R152-P102J
4R39	0.22 megohm.	C-3R152-P224J
4R40	5100 ohms, ½ w.	C-3R77-P512J
4R41	0.30 megohm.	C-3R152-P304J
4R42	100 ohms.	C-3R152-P101J
4R43	68,000 ohms.	C-3R152-P683J
4R44	0.15 megohm.	C-3R152-P154J
4R45	39,000 ohms.	C-3R152-P393J
4R46	47,000 ohms.	C-3R152-P473J
4R47	Precision, wirewound; 62 ohms ± 1%, 2.5 w.	C-7778027-P135
4R48	3900 ohms.	C-3R152-P392J
4R49	1800 ohms, ½ w.	C-3R77-P182J
4R50	33,000 ohms.	C-3R152-P333J
4R51	1500 ohms.	C-3R152-P152J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
4R52	2000 ohms.	C-3R152-P202J
4R53	10,000 ohms.	C-3R152-P103J
4R54	Precision; 2740 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P2741
4R55	Precision; 1330 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1331
4R57	39,000 ohms.	C-3R152-P393J
4R58	10,000 ohms.	C-3R152-P103J
4R59	33,000 ohms.	C-3R152-P333J
4R60	470 ohms.	C-3R152-P471J
4R61 and 4R62	10,000 ohms.	C-3R152-P103J
4R63	2200 ohms.	C-3R152-P222J
4R64	Potentiometer, carbon composition; 50,000 ohms ± 3%, 0.25 w.	B-7399124-P9
4R65	Precision; 182,000 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1823
4R66	10,000 ohms.	C-3R152-P103J
4R67	22,000 ohms.	C-3R152-P223J
4R68 thru 4R70	1000 ohms.	C-3R152-P102J
4R71	10,000 ohms.	C-3R152-P103J
4R72 and 4R73	1000 ohms.	C-3R152-P102J
4R74	10,000 ohms.	C-3R152-P103J
4R75	Precision; 121,000 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1213
4R76	4700 ohms.	C-3R152-P472J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
4R77	15,000 ohms.	C-3R152-P153J
4R78	56,000 ohms.	C-3R152-P563J
4R79	2200 ohms, $\frac{1}{2}$ w.	C-3R77-P222J
4R80	15,000 ohms.	C-3R152-P153J
4R81	68,000 ohms.	C-3R152-P683J
4R82	Potentiometer, carbon composition; 10,000 ohms ± 30%, 0.25 w.	B-7399124-P6
4R83	0.22 megohm.	C-3R152-P224J
4R84	47,000 ohms.	C-3R152-P473J
4R85	150 ohms.	C-3R152-P151J
4R86	Potentiometer, carbon composition; 500 ohms ± 30%, 0.25 w.	B-7399124-P1
4R87	330 ohms.	C-3R152-P331J
4R88	2000 ohms.	C-3R152-P202J
4R89	1000 ohms, $\frac{1}{2}$ w.	C-3R77-P102J
4R90	10,000 ohms.	C-3R152-P103J
4R91	3300 ohms.	C-3R152-P332J
4R92	2200 ohms.	C-3R152-P222J
4R93	3300 ohms.	C-3R152-P332J
	CRYSTAL	
4Y1	Frequency 15.75 kHz.	B-7499796-P6
	Frequency 20.25 kHz.	B-7499796-P8

Part No.	Description	GE Drawing
	SYNC GENERATOR KIT PL-7399144G1	
	MECHANICAL PARTS	
2	Chassis.	PL-7399172-G1
3	Insulator.	A-7199156-P1
4	Screws. (Qty. 8.) GE Type N81P09004C13.	
5	Rail. (Qty. 2.)	A-7199155-P1
6	Screws. (Qty. 4.) GE Type N83P09005C13.	
	SYNC GENERATOR BOARD PL-7699914G1	
Symbol		
	CAPACITORS	
C1 and C2	Electrolytic, tubular; 500 mfd +75% -10%, 12 v d-c w. General Instrument Cat. #974-176.	B-7489483-P47
C4	Polyester; 0.10 mfd ± 20%, 50 v d-c w.	H604AC-P4101
C5 and C6	Silver mica, epoxy dipped; 220 pf ± 2%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P235
C7	Electrolytic, solid tantalum type; 6.8 mfd ± 20%, 35 v d-c w. TI Type SCM685BP035C4, Sprague Type 150D685X0035B2.	B-7493471-P7
C8	Electrolytic, solid tantalum type; 1.0 mfd ± 20%, 35 v d-c w. TI Type SCM105FP035C4, Sprague Type 150D105X0035A2.	B-7493471-P2
C9	Electrolytic, solid tantalum type; 22 mfd ± 20%, 35 v d-c w. TI Type SCM226GP035C4, Sprague Type 150D226X0035R2.	B-7493471-P8
C10	Electrolytic, solid tantalum type; 2.2 mfd ± 20%, 20 v d-c w. TI Type SCM225FP020C4, Sprague Type 150D225X0020A2.	B-7493471-P13

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED)	
C11	Silver mica, epoxy dipped; 270 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P37
C12	Polyester; 0.010 mfd ± 10%, 50 v.	H604AC-3102
	RECTIFIERS	
CR1 thru CR4	Silicon rectifiers; 200 PIV. GE Type A13B2, A14B, 1N5059.	B-7499220-P2
CR5 and CR6	GE Type 1N4454.	A-7164424-P104
	TRANSISTORS	
Q1 thru Q5	GE Type 2N3415.	A-7164451-P213
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
R1	22 ohms, $\frac{1}{2}$ w.	C-3R77-P220J
R2	680 ohms.	C-3R152-P681J
R3 and R4	2200 ohms.	C-3R152-P222J
R5	Precision; 100,000 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1003
R6	Precision; 107,000 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1073
R7	Variable trimmer, single turn; 25,000 ohms ± 10%, $\frac{1}{2}$ w. Allen Bradley Type SV.	C-7799613-P4
R8 and R9	3300 ohms.	C-3R152-P332J
R10	Precision; 1210 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P1211

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified.)	
R11	75,000 ohms.	C-3R152-P753J
R12	Precision; 3320 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P3321
R13	10,000 ohms.	C-3R152-P103J
R14	3300 ohms.	C-3R152-P332J
R15 thru R17	2200 ohms.	C-3R152-P222J
R18	220 ohms.	C-3R152-P221J
R19	680 ohms.	C-3R152-P681J
	INTEGRATED CIRCUITS	
Z1 thru Z11	Clocked flip-flop. Motorola Cat. #MC845P.	C-7782517-P1
Z12	Dual 4-input power gates. Motorola Cat. #MC844P.	C-7782402-P1
Z13	Dual, 4-input gate expanders. Motorola Cat. #MC833P.	C-7782407-P1

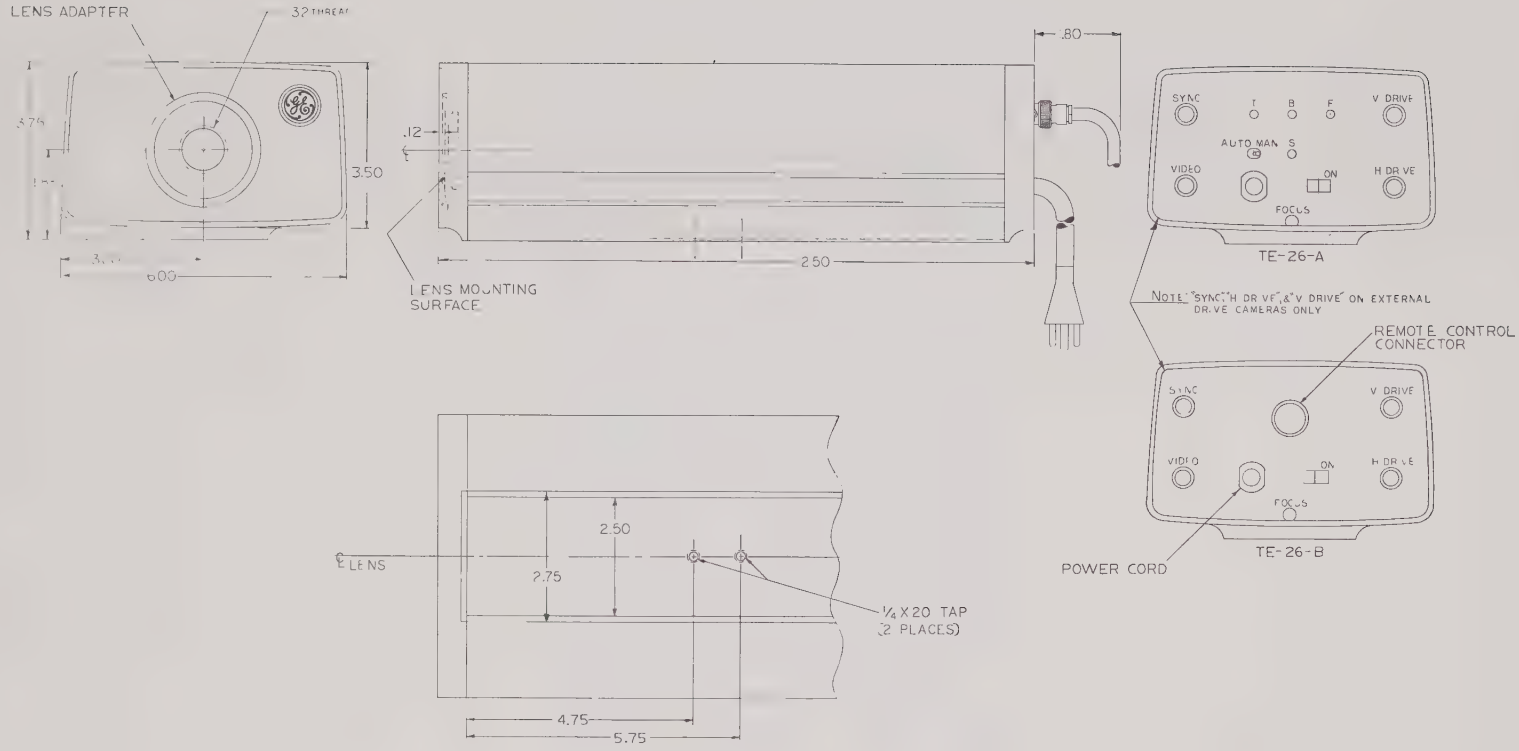


Fig. 1 Camera Outline Diagram (D-7699956)

EBI-6286

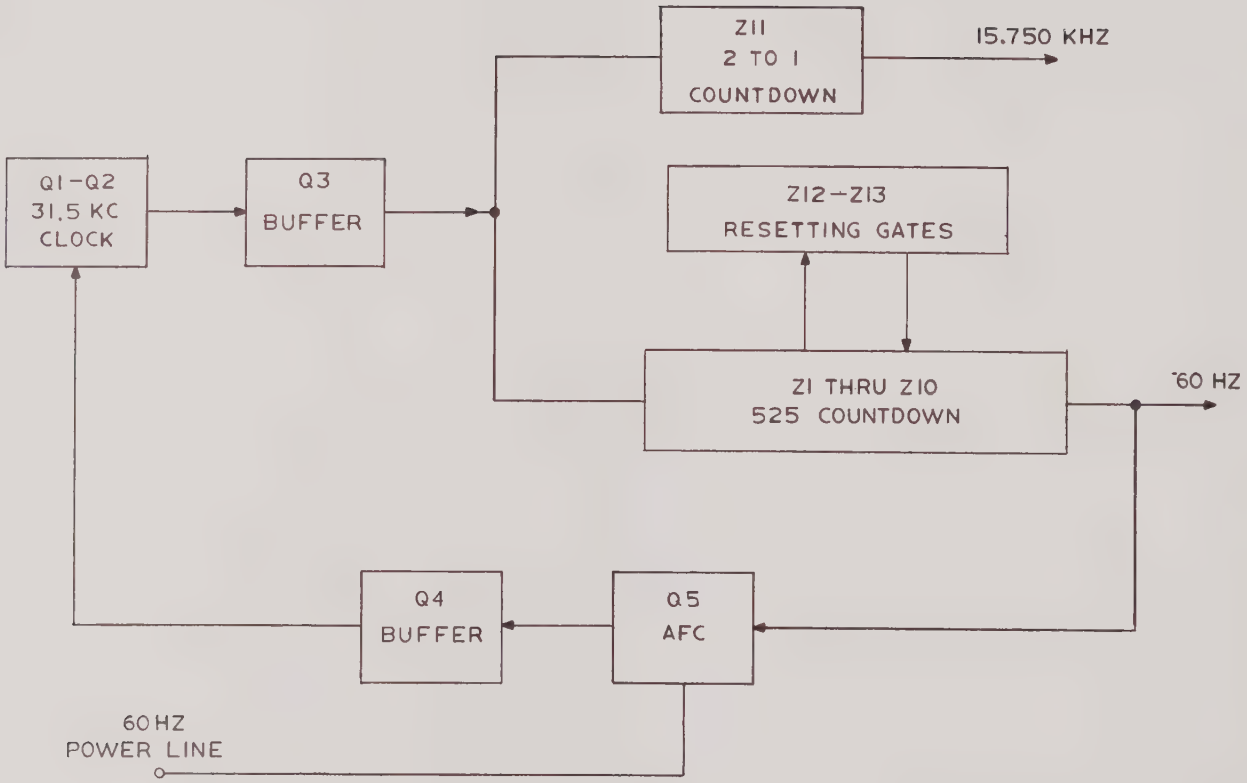


Fig. 2 Sync Generator Board Block Diagram (C-7799654)

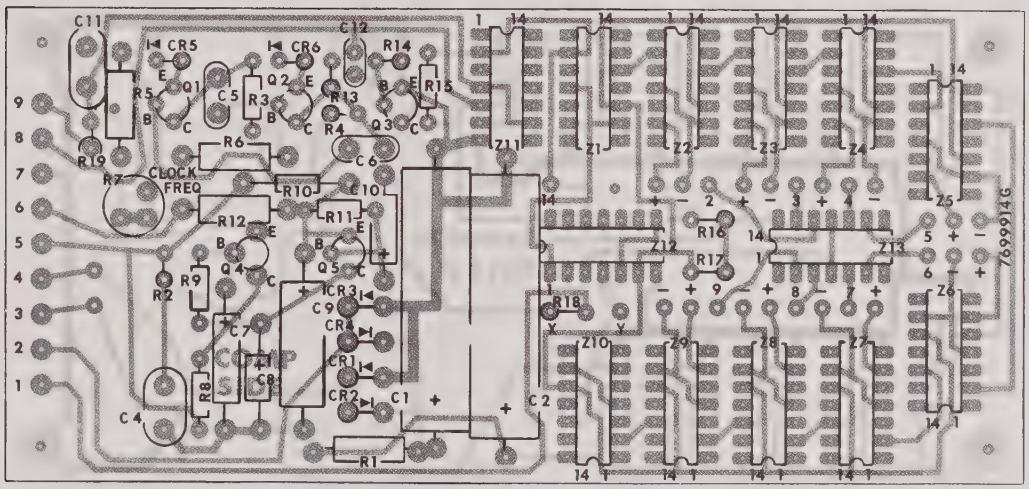
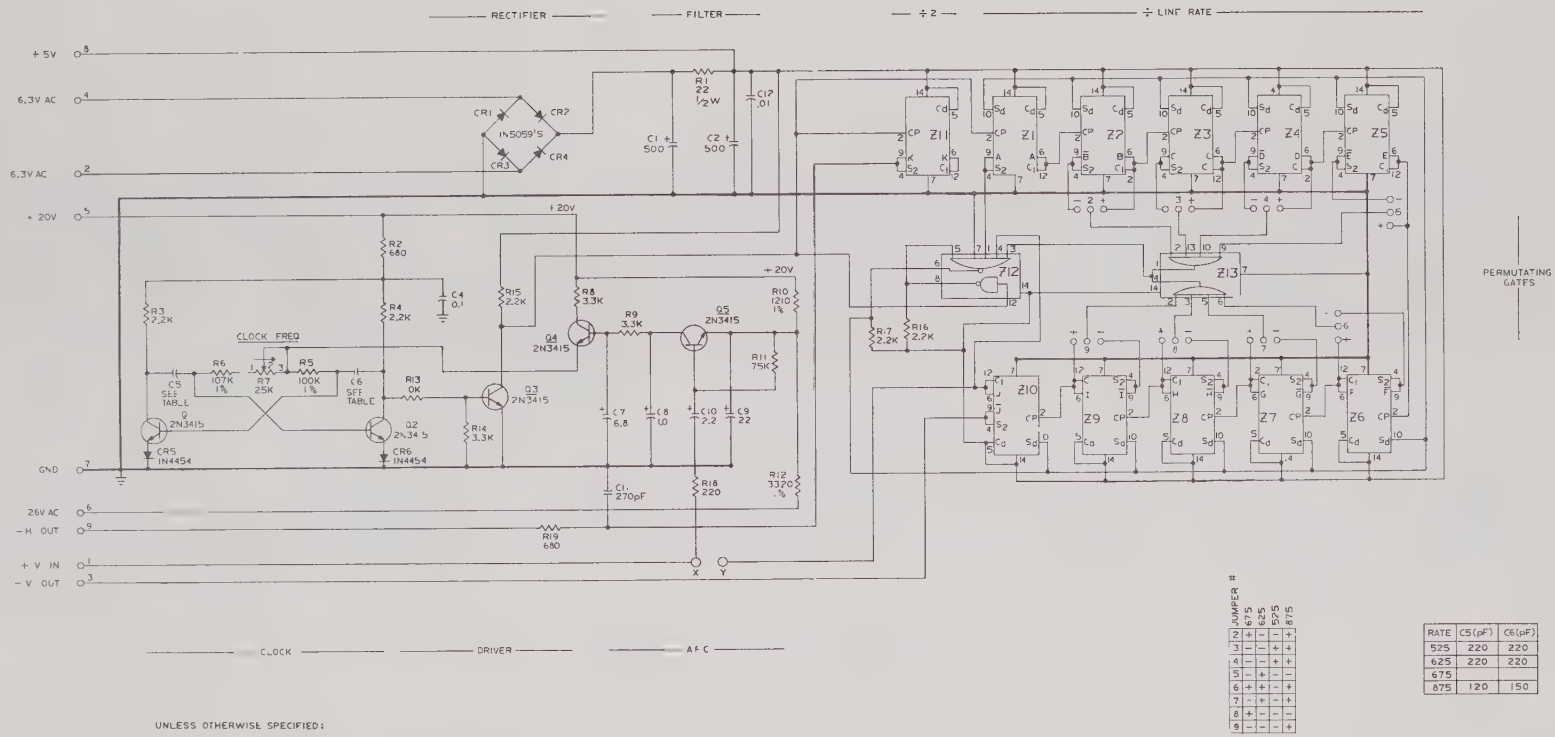


Fig. 3 Sync Generator Board Printed Circuit Diagram (D-7699876, Patt C)



JUMPER #	675	625	525	875
2	+	-	-	+
3	-	-	+	+
4	-	-	+	+
5	-	+	-	-
6	+	+	-	+
7	-	+	-	+
8	+	-	-	-
9	-	-	-	+

RATE	C5(pF)	C6(pF)
525	220	220
625	220	220
675		
875	120	150

UNLESS OTHERWISE SPECIFIED:

ALL RESISTOR VALUES ARE IN OHMS TOL ± 5% AND 1/4 WATT.

ALL CAPACITOR VALUES ARE IN MICROFARADS, pF = PICOFARADS.

Fig. 4 Sync Generator Board Schematic Diagram (DD-7699933)

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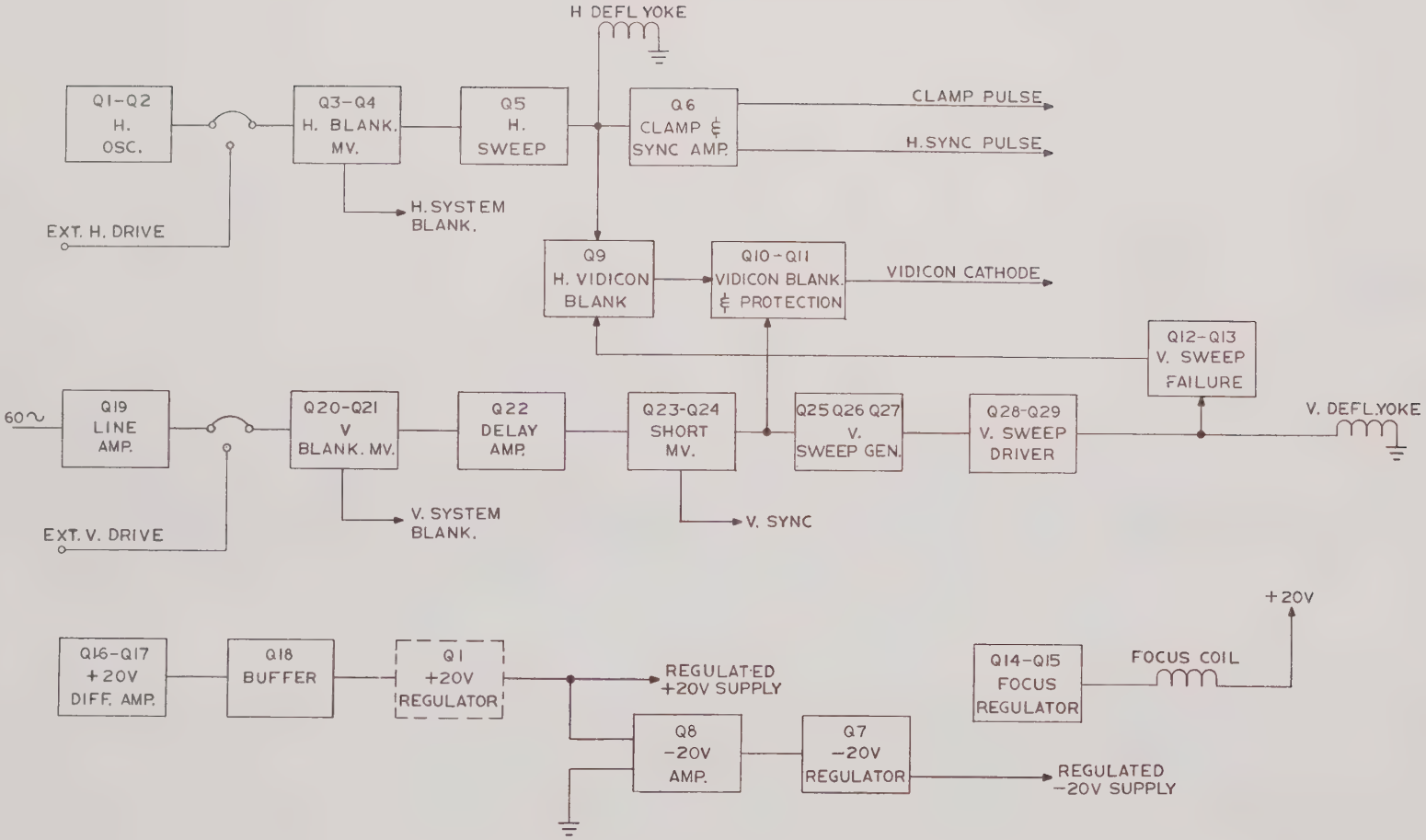


Fig. 5 Power-Sweep Board Block Diagram (C-7799651)

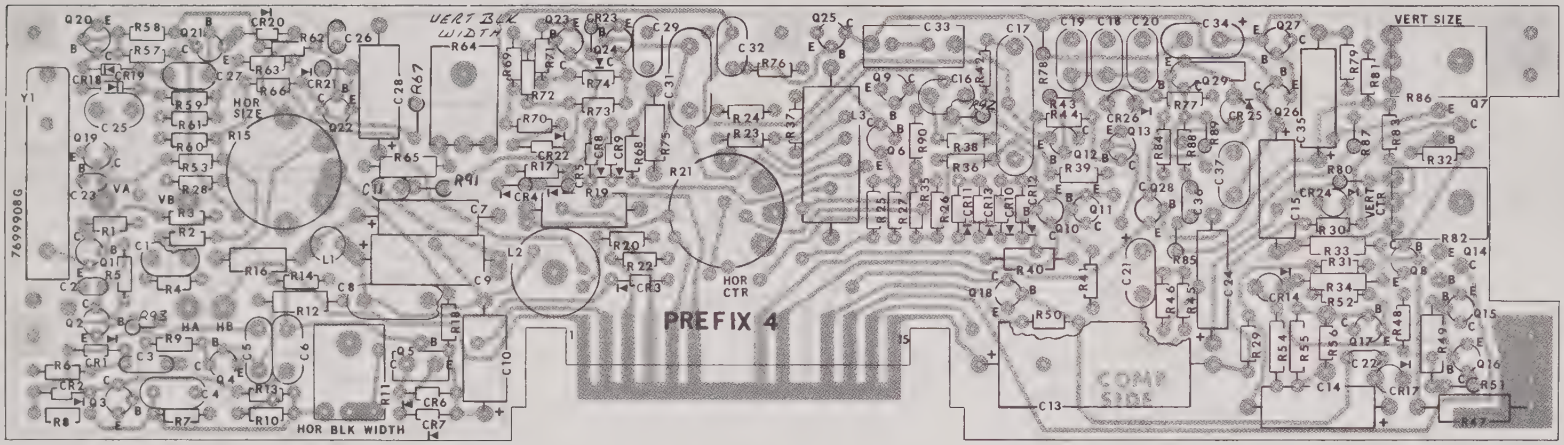
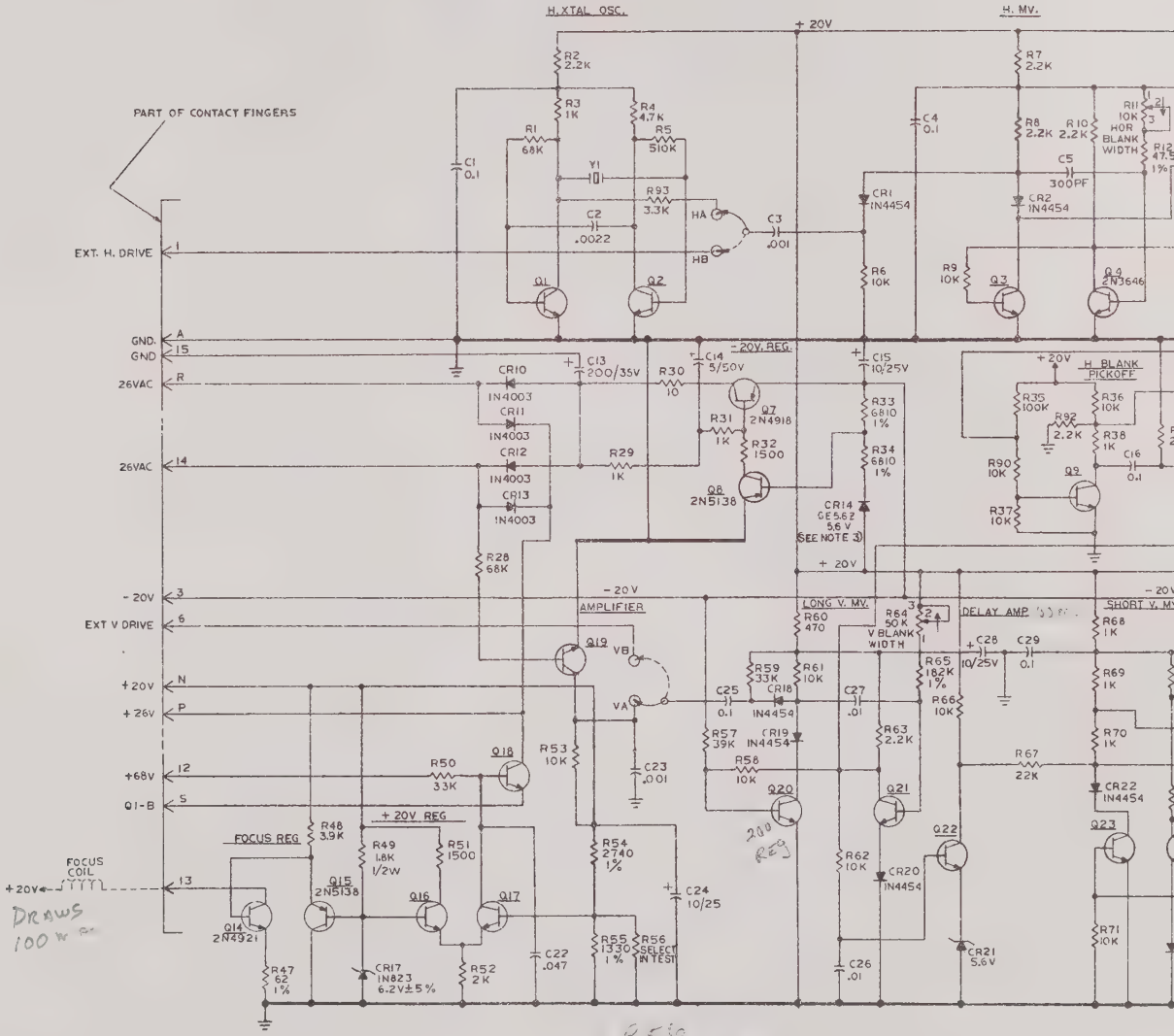


Fig. 6 Power-Sweep Board Printed Circuit Diagram (D-7699882, Patt D, Rev. C)

EBI-6286


H. XTAL OSC.
+ 20V
H. MV.
PART OF CONTACT FINGERS
EXT. H. DRIVE
GND.
GND
26VAC
26VAC
- 20V
EXT V DRIVE
+ 20V
+ 26V
+68V
Q1-B
FOCUS COIL
+20V
DRAWS 100 MA
FOCUS REG
+ 20V REG
- 20V REG.
AMPLIFIER
LONG V. MV.
V BLANK WIDTH
DELAY AMP
SHORT V. MV
H BLANK PICKOFF
HOR BLANK WIDTH
SEE NOTE 3
200 MA
R56 SELECT IN TEST

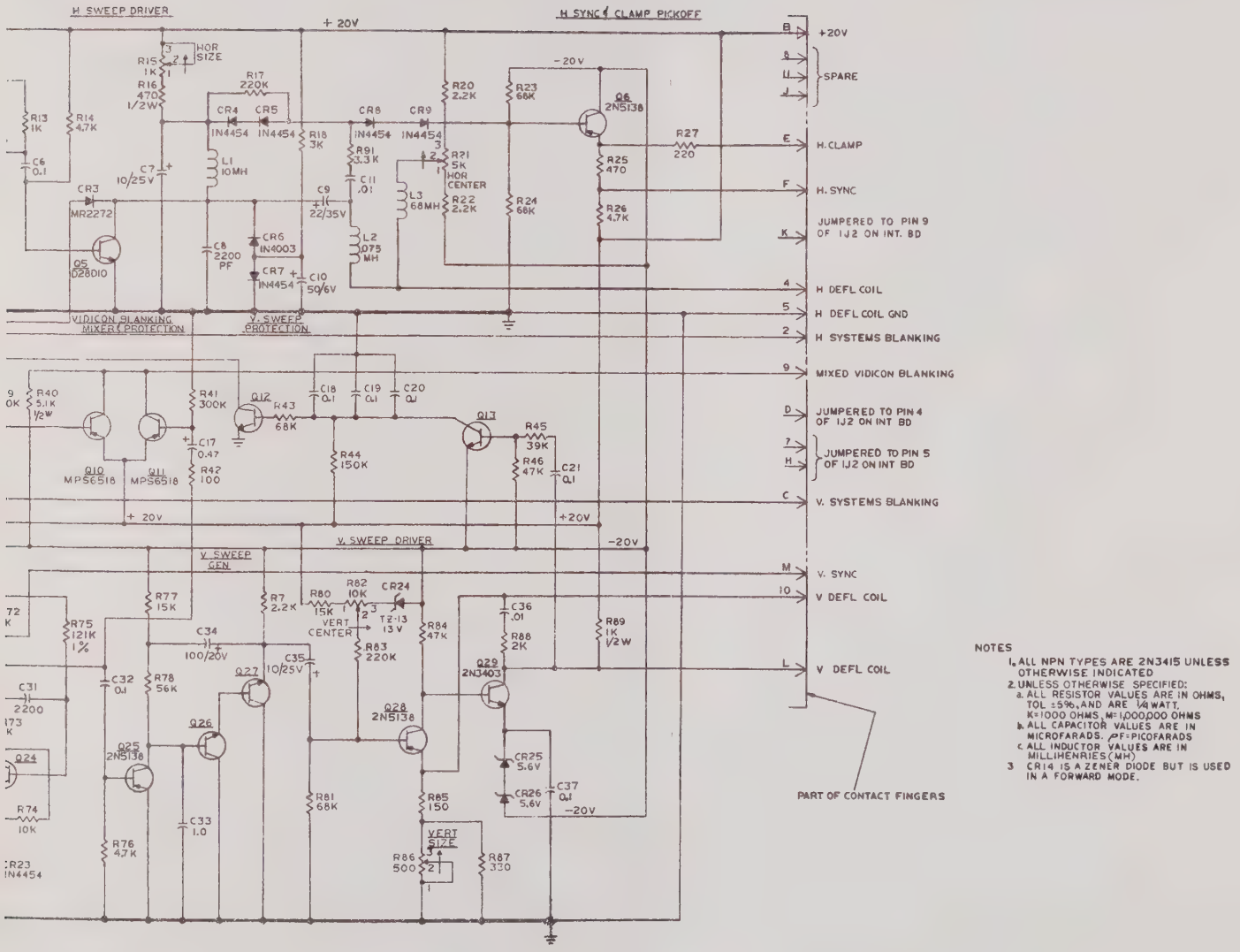


Fig. 7 Power-Sweep Board Schematic Diagram (D-7699913, Rev. B)

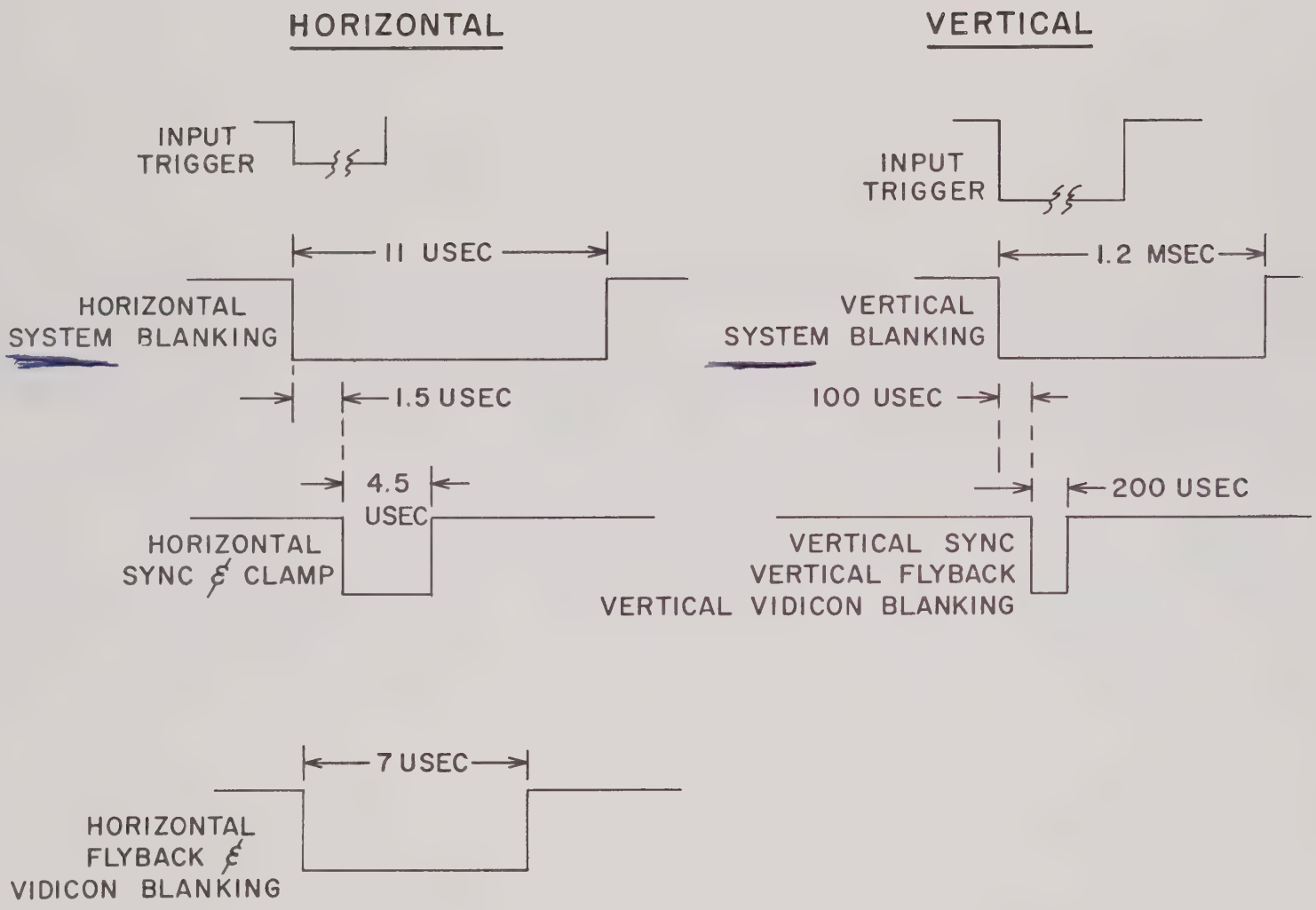


Fig. 8 Vertical and Horizontal Waveforms Showing Timing Relationships

EBI-6286

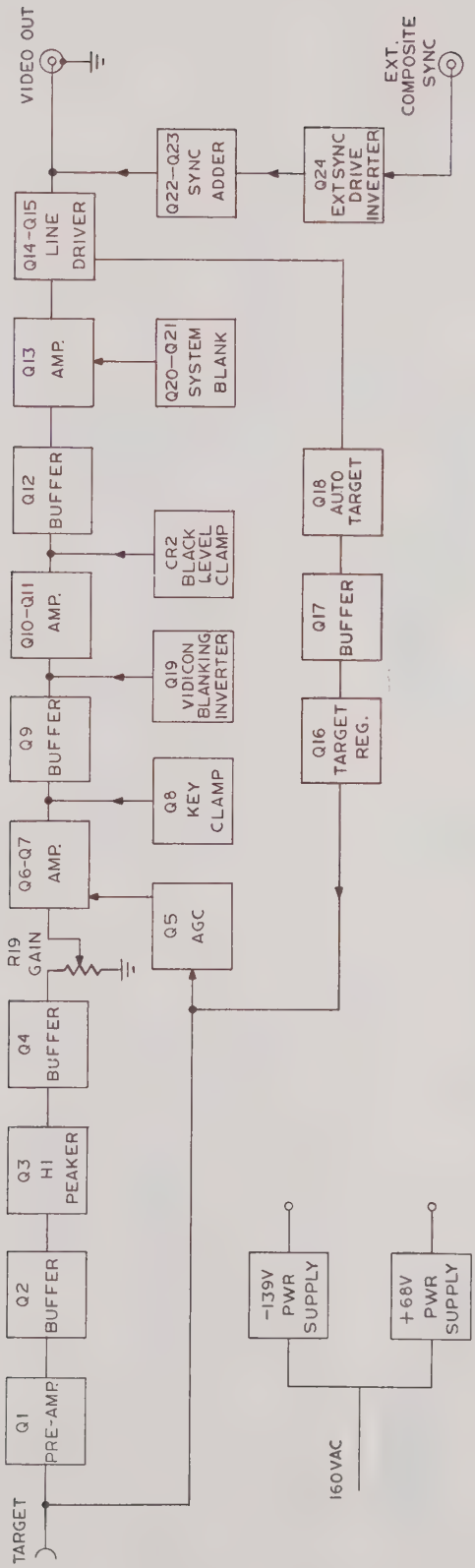


Fig. 9 Video Board Block Diagram (C-7799652)

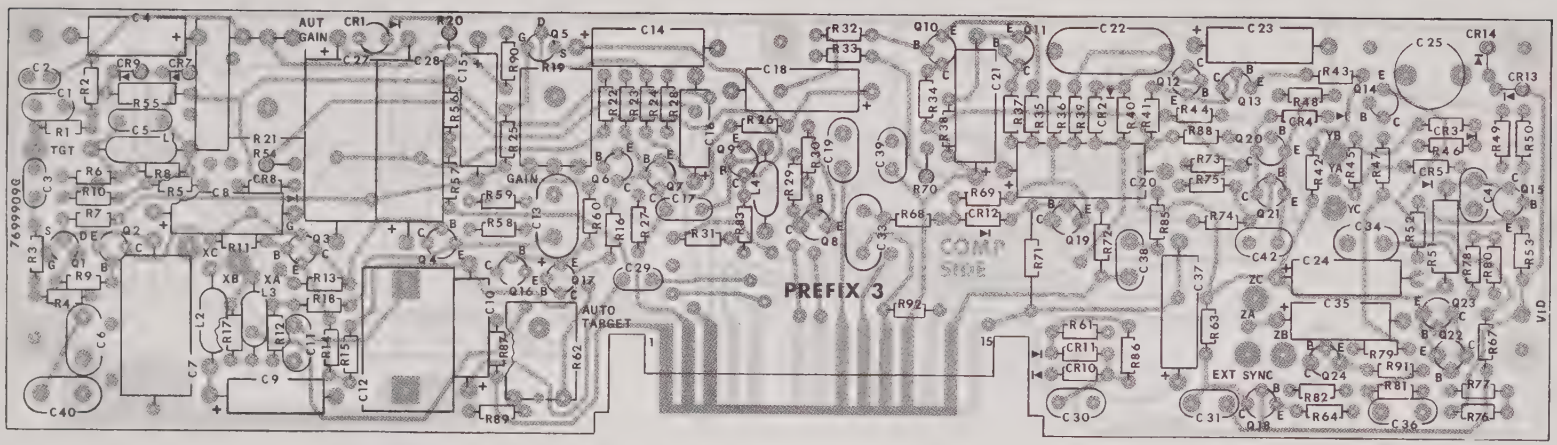
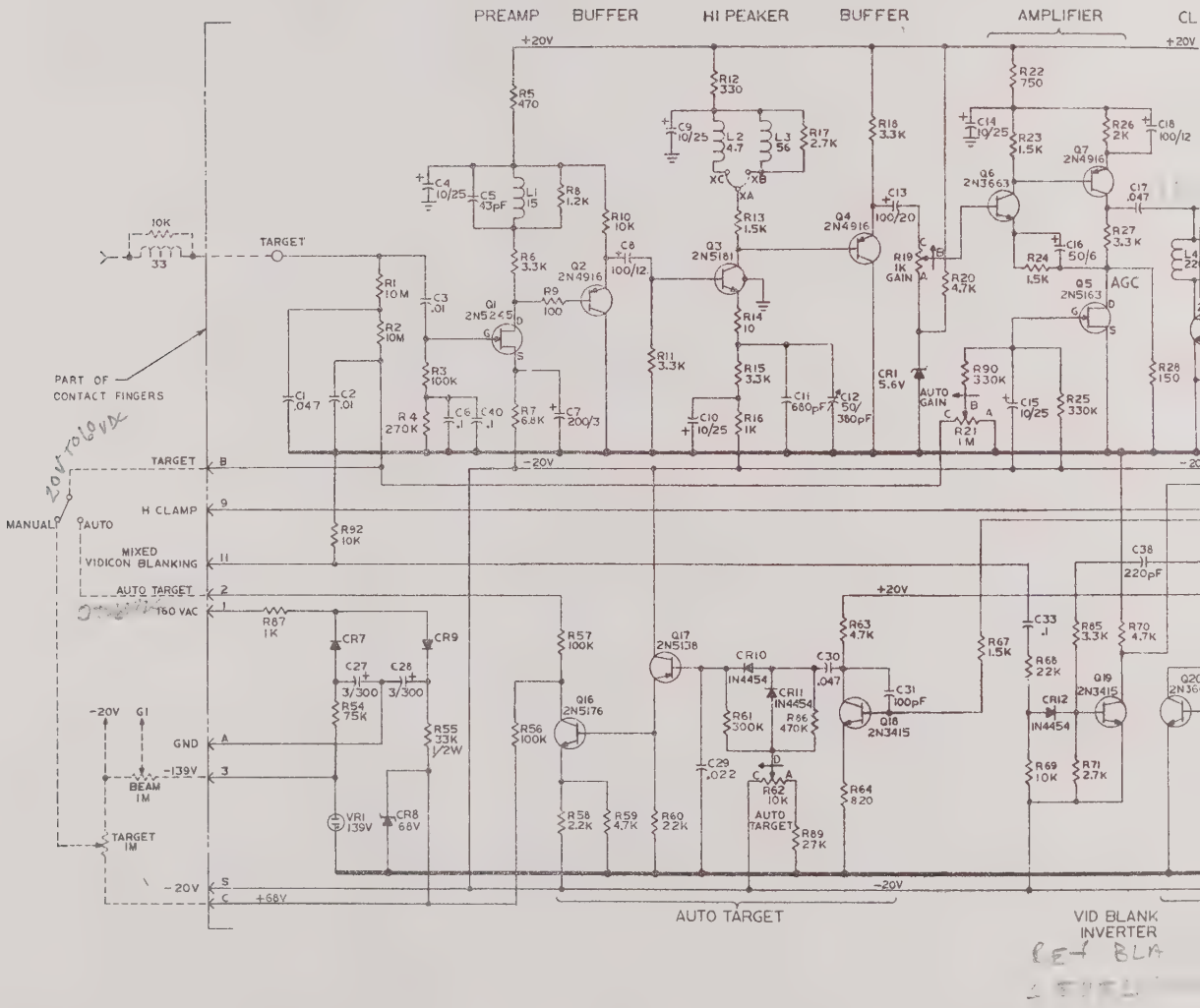


Fig. 10 Video Board Printed Circuit Diagram (D-7699894, Patt D, Rev. D)


PREAMP
BUFFER
HI PEAKER
BUFFER
AMPLIFIER
+20V
-20V
TARGET
MANUAL
AUTO
H CLAMP
MIXED VIDICON BLANKING
AUTO TARGET
160 VAC
GND
-139V
BEAM 1M
TARGET 1M
+68V
PART OF CONTACT FINGERS
AUTO GAIN
AGC
AUTO TARGET
VID BLANK INVERTER

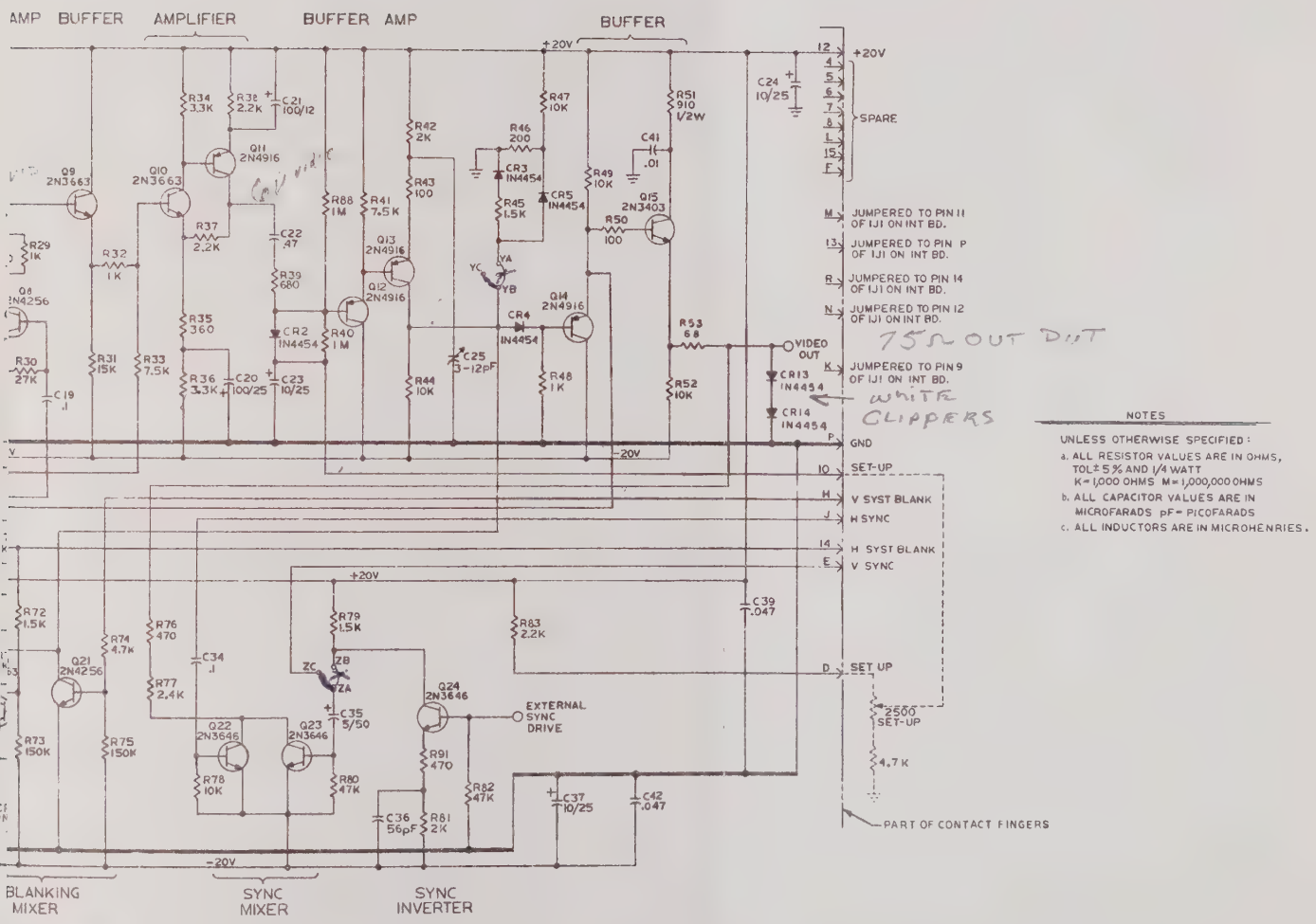


Fig. 11 Video Board Schematic Diagram (D-7699912, Rev. A)

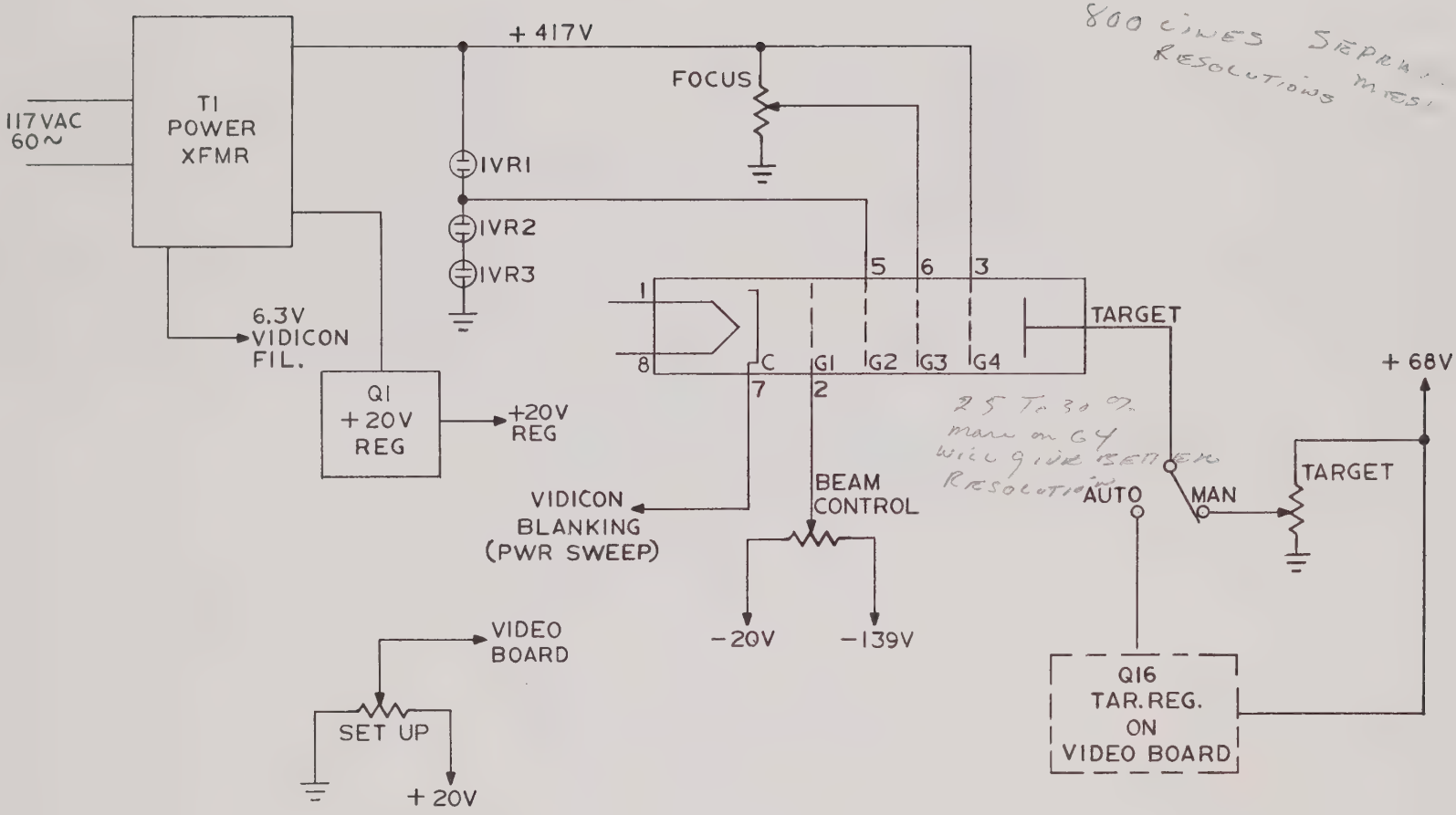


Fig. 12 Interconnection Board Block Diagram (C-7799653)

EBI-6286

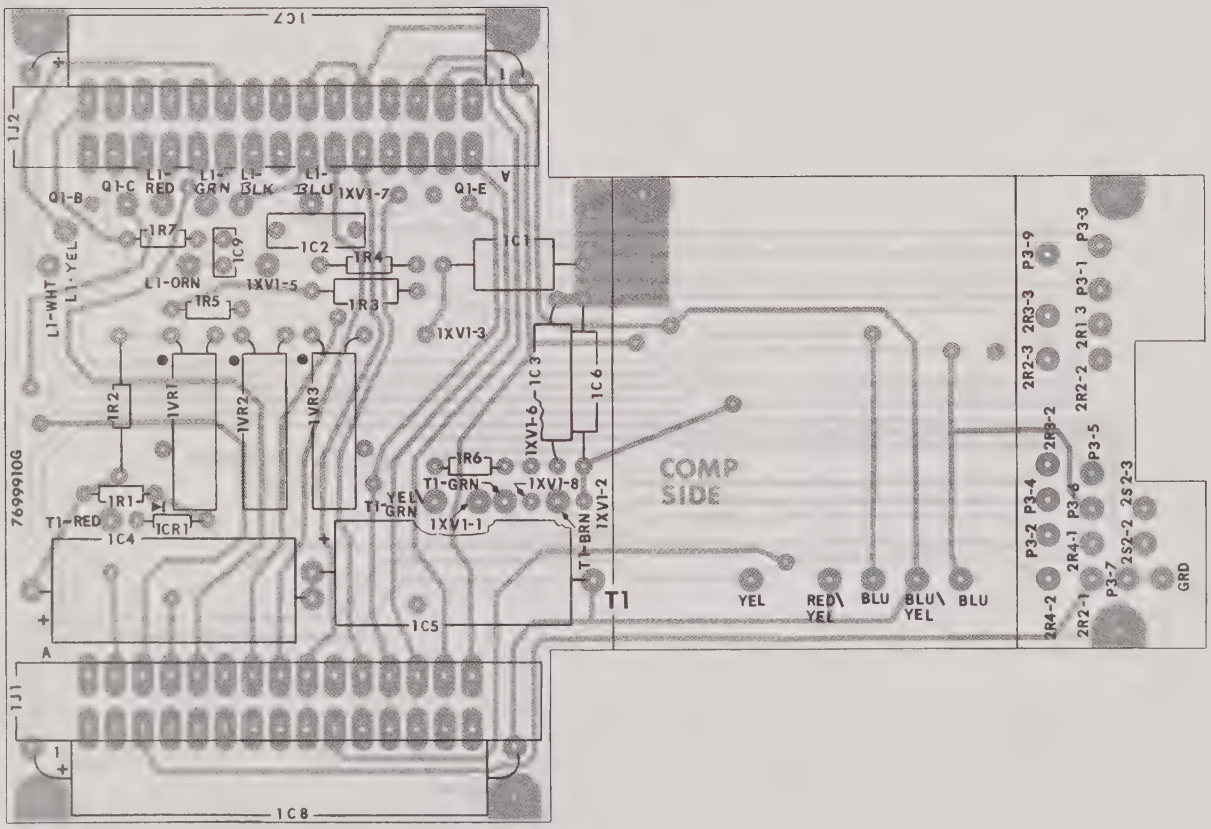
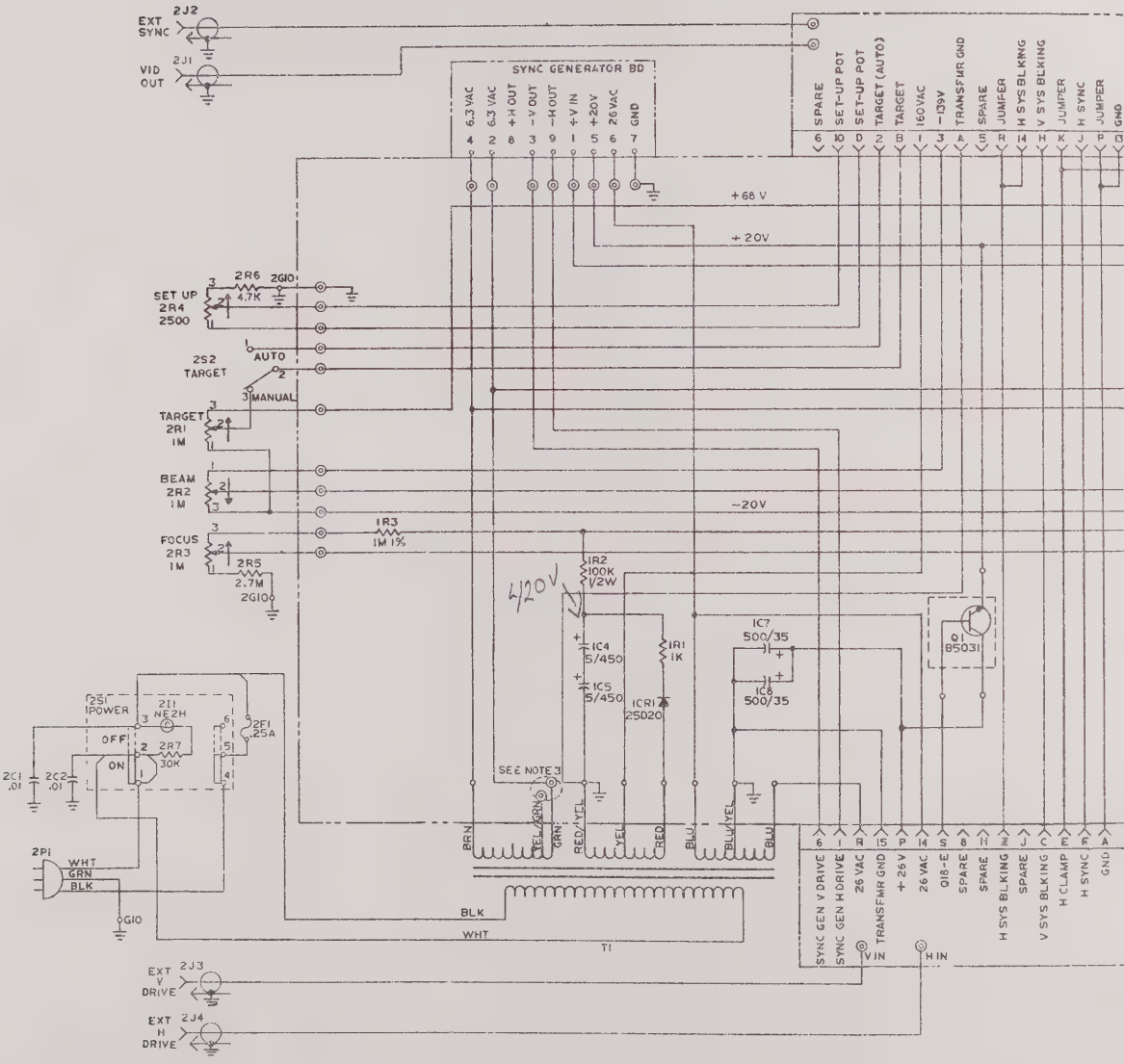
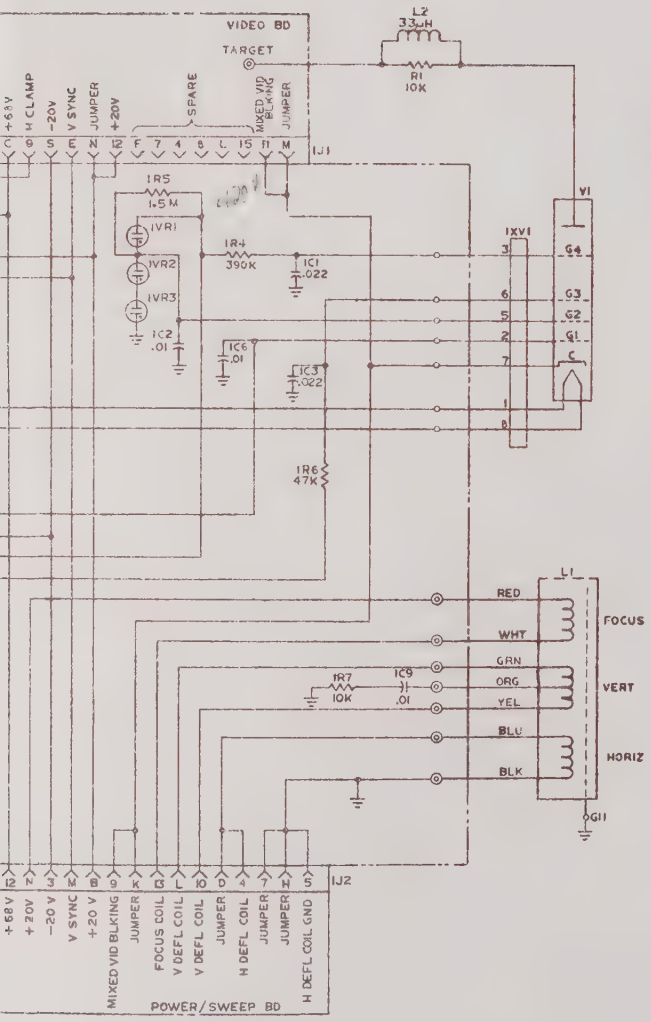


Fig. 13 Interconnection Board Printed Circuit Diagram (D-7699895, Patt C, Rev. B)

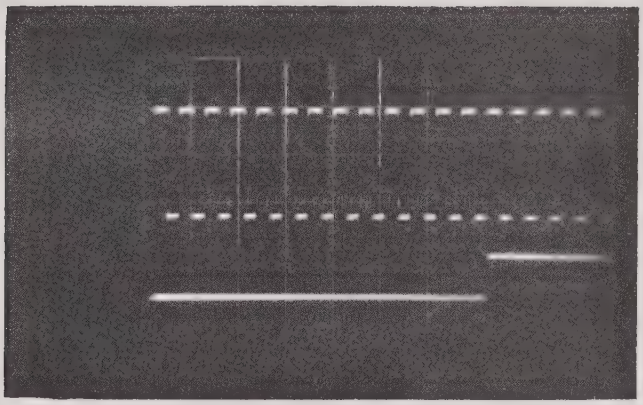

EXT SYNC
2J2
VID OUT
2J1
SYNC GENERATOR BD
6.3 VAC
6.3 VAC
+H OUT
-V OUT
-H OUT
+V IN
+20V
26 VAC
GND
SPARE
SET-UP POT
SET-UP POT
TARGET (AUTO)
TARGET
160 VAC
-139V
TRANSFMR GND
SPARE
JUMPER
H SYS BLKING
V SYS BLKING
JUMPER
H SYNC
JUMPER
GND
+68 V
+20V
-20V
SET UP 2R4 2500
2R6 4.7K
2G10
2S2 TARGET
AUTO
MANUAL
TARGET 2R1 1M
BEAM 2R2 1M
FOCUS 2R3 1M
1R3 1M 1%
2R5 2.7M
2G10
1R2 100K 2W
5/20V
IC4 5/450
IC5 5/450
1R1 1K
IC7 500/35
IC8 500/35
ICR1 25020
Q1 B5031
2S1 POWER
2I1 NE2H
2F1 .25A
OFF
ON
2R7 30K
2C1 .01
2C2 .01
2P1
WHT
GRN
BLK
G10
SEE NOTE 3
BRN
YEL/GRN
GRN
RED/YEL
YEL
RED
BLU
BLU/YEL
BLU
BLK
WHT
T1
SYNC GEN V DRIVE
SYNC GEN H DRIVE
26 VAC
TRANSFMR GND
+26 V
26 VAC
Q1B-E
SPARE
SPARE
H SYS BLKING
SPARE
V SYS BLKING
H CLAMP
H SYNC
GND
V IN
H IN
EXT V DRIVE
2J3
EXT H DRIVE
2J4



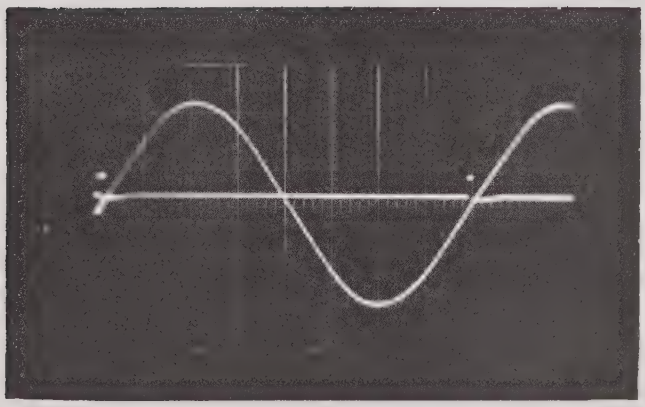
NOTES

1. RESISTOR VALUES ARE IN OHMS AND 1/4 WATT UNLESS OTHERWISE SHOWN. K=1,000 OHMS, M=1,000,000 OHMS.
2. CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SHOWN. pF=PICOFARADS.
3. WHEN USING 0.6A. FILAMENT VIDICONS (7735,8507) PLUG T-1 GREEN LEAD INTO PIN IDENTIFIED "GRN" PLUG T-1 YELLOW/GREEN LEAD INTO PIN IDENTIFIED "YEL/GRN"
   WHEN USING 90MA FILAMENT VIDICONS (8541) PLUG T-1 GREEN LEAD INTO PIN IDENTIFIED "YEL/GRN" PLUG T-1 "YEL-GRN" INTO PIN IDENTIFIED "GRN"

Fig. 14 Interconnection Board Schematic Diagram (D-7699911, Rev. B)

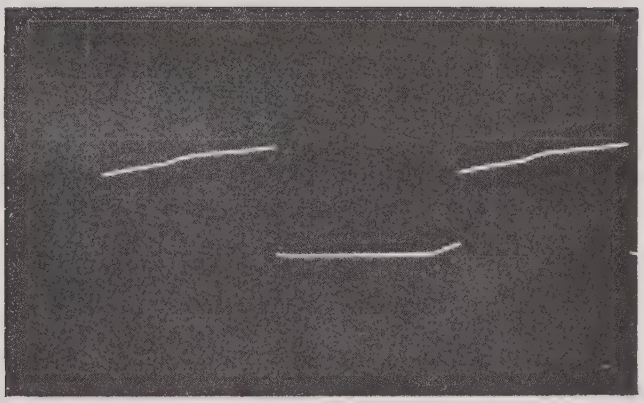


(a) Two Probes: 1 - Pin 3 Output, Negative Vertical Pulse, 5 v/cm; 2 - Q2 Collector, 31.5-kHz Clock Pulse, 5 v/cm. Correct counting indicated when 13 clock pulses (at 525-line rate) fall within the vertical pulse period.

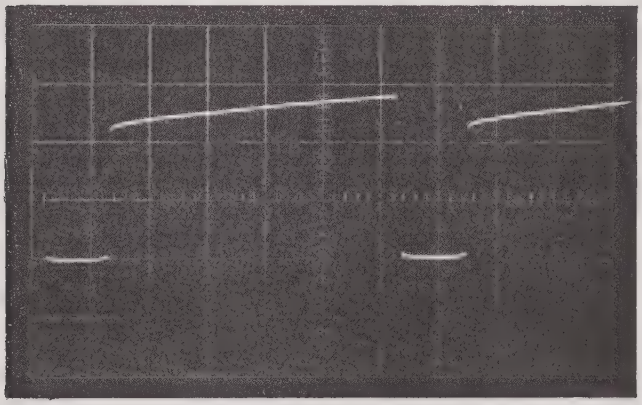


(b) Two Probes: 1 - Q5 Emitter, 60-Hertz Sine Wave, 0.5 v/cm; 2 - Pin 1 Input, 0.5 v/cm

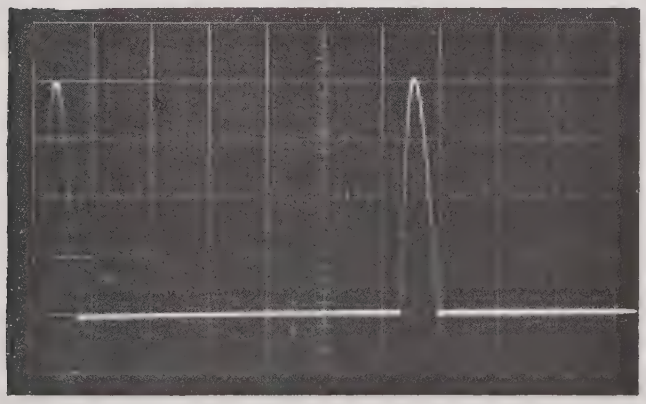
Fig. 15 Sync Generator Waveforms



(a) Q1 Collector: 5 v/cm, H rate

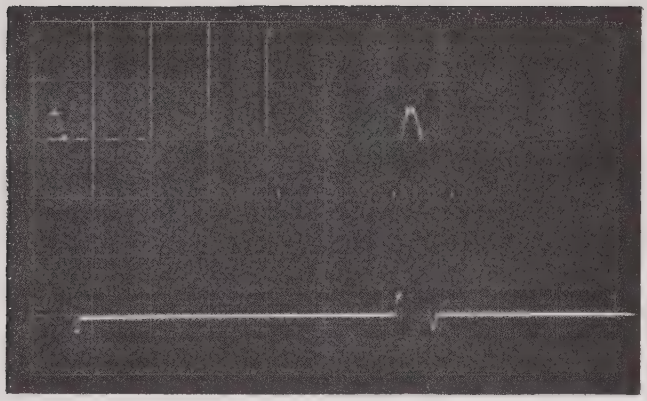


(b) Q3 Collector: 2 v/cm, H rate

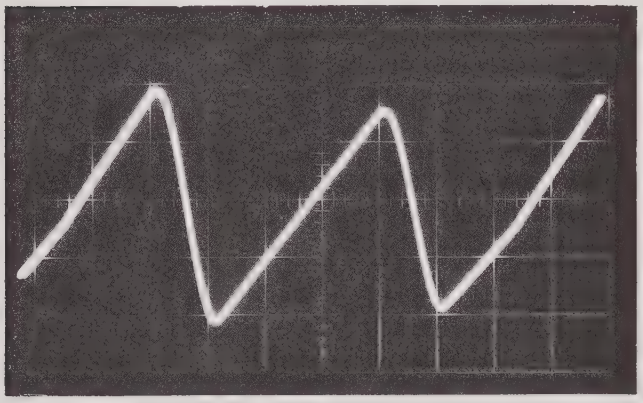


(c) Q5 Collector: 20 v/cm, H rate

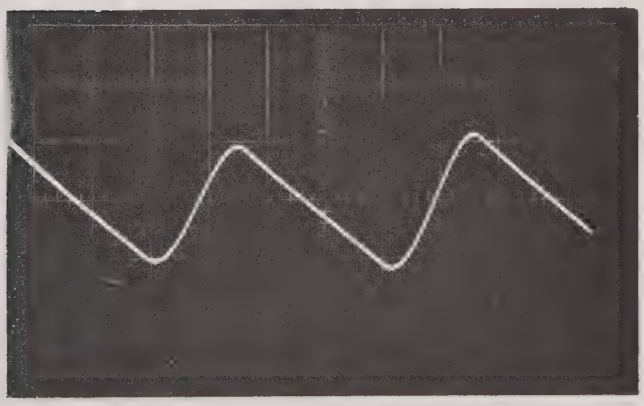
Fig. 16 Power-Sweep Board Waveforms (a-c)



(d) Q6 Emitter: 2 v/cm, H rate

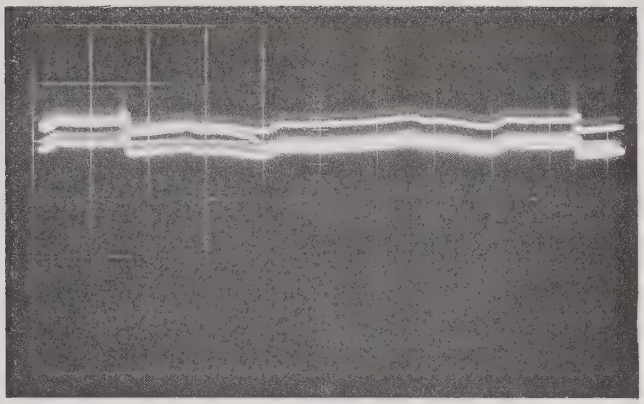


(e) Minus Side of C13: 0.5 v/cm, V rate

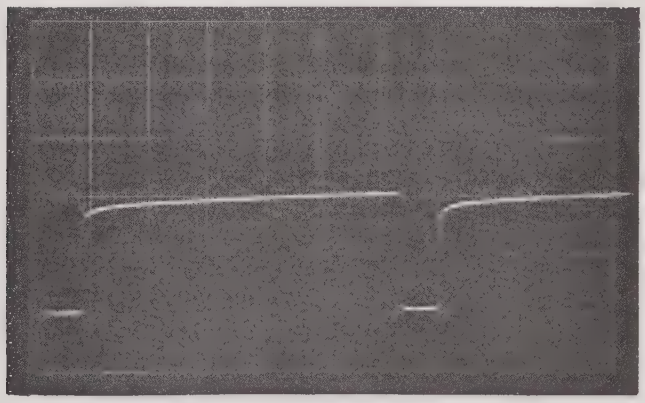


(f) Plus Side of C1: 0.5 v/cm, V rate

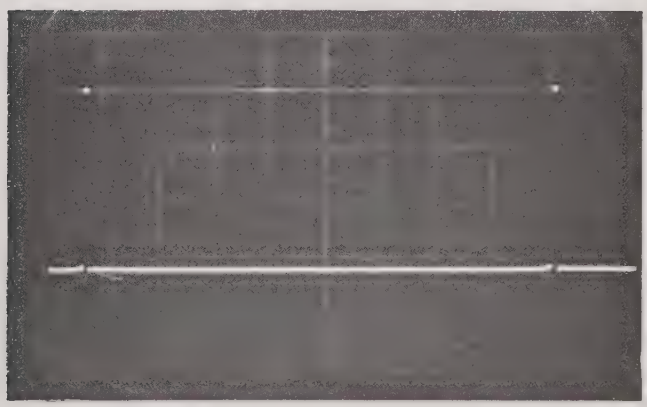
Fig. 17 Power-Sweep Board Waveforms (d-f)



(g) Minus Side of C15: 0.05 v/cm, V rate

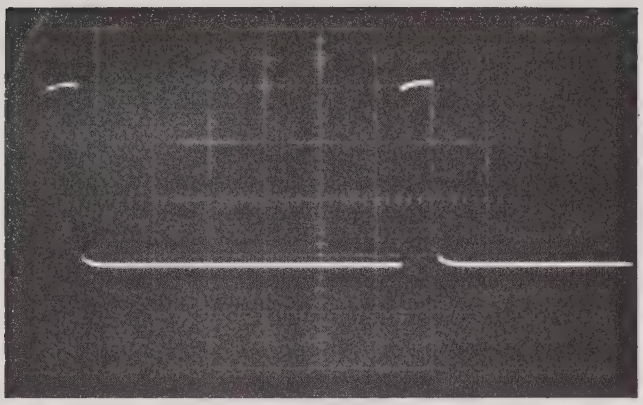


(h) Q9 Collector: 2 v/cm, H rate

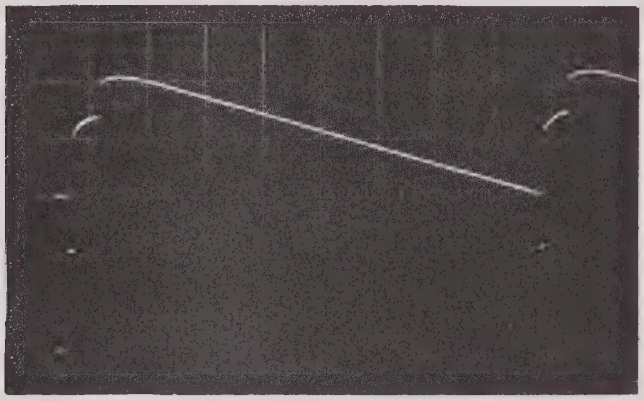


(i) Q10 and Q11 Collector: 10 v/cm, V rate

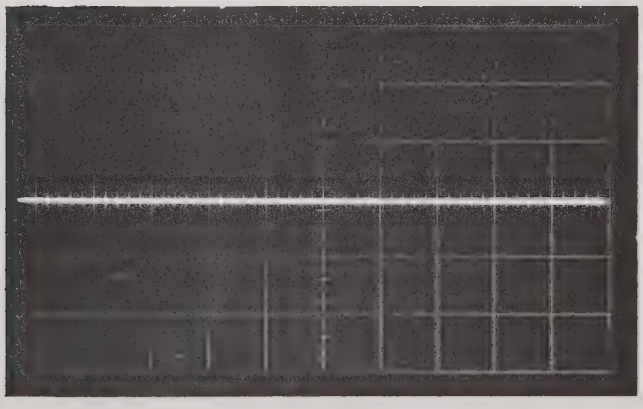
Fig. 18 Power-Sweep Board Waveforms (g-i)



(j) Q10 and Q11 Collector: 10 v/cm, H rate

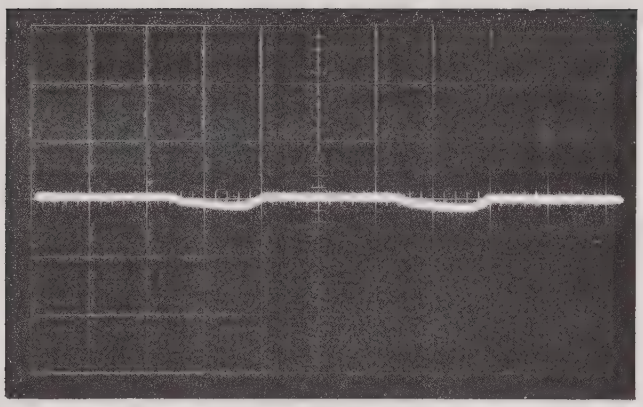


(k) Q11 Base: 1 v/cm, V rate

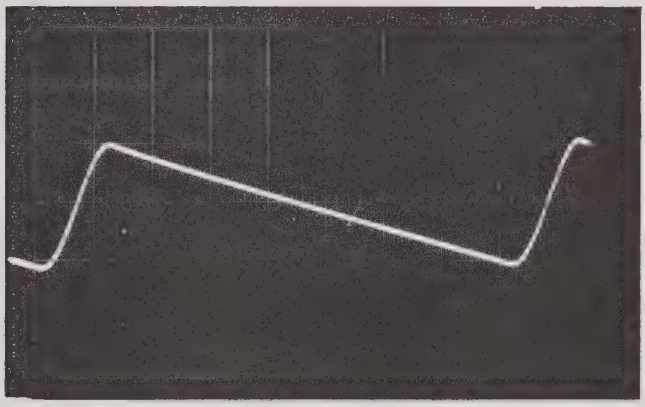


(l) Q14 Emitter: 2 v/cm, V rate

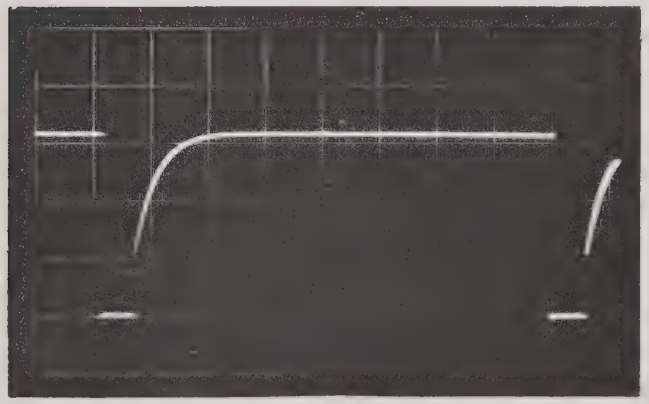
Fig. 19 Power-Sweep Board Waveforms (j-l)



(m) Plus Side of C24: 0.05 v/cm, V rate

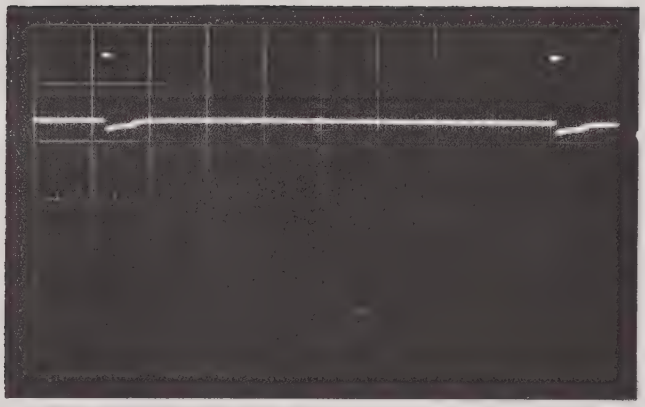


(n) Plus Side of 1C4 on Interconnection Board: 5 v/cm, V rate

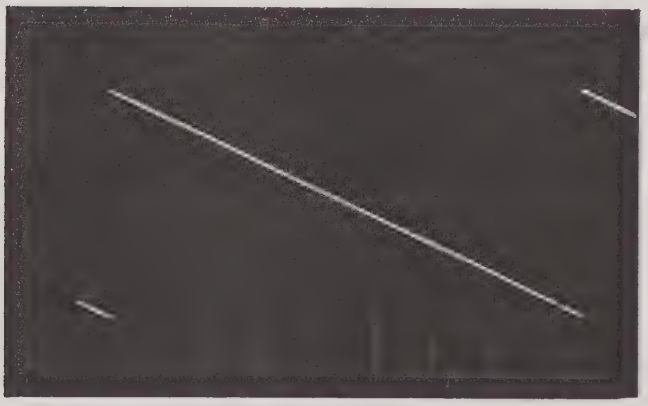


(o) Q21 Collector: 5 v/cm, V rate

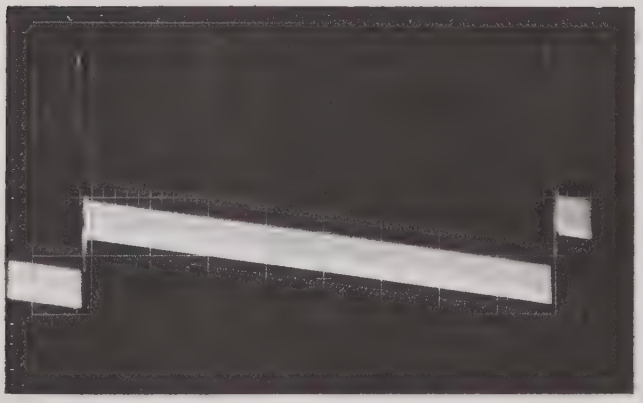
Fig. 20 Power-Sweep Board Waveforms (m-o)



(p) Junction of R72 and R73: 2 v/cm, V rate

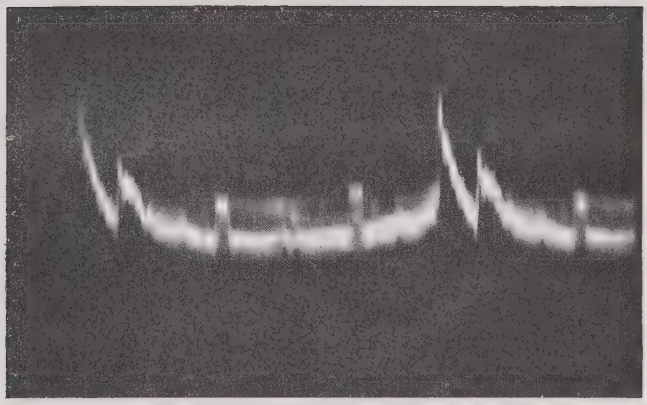


(q) Q28 Emitter: 1 v/cm, V rate

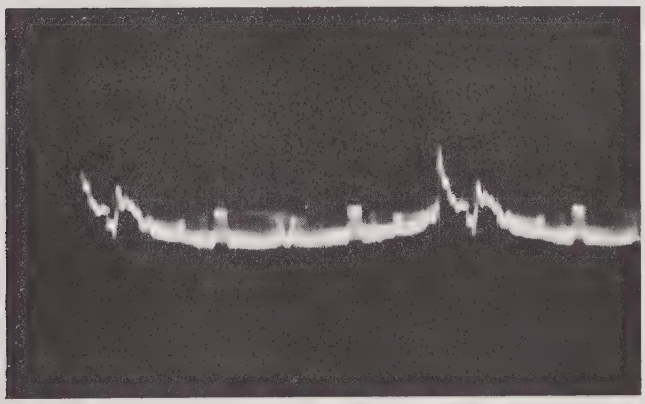


(r) Q29 Collector: 5 v/cm, V rate

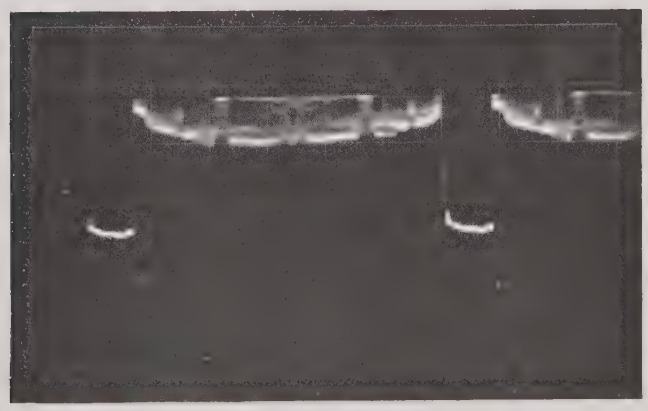
Fig. 21 Power-Sweep Board Waveforms (p-r)



(a) Q4 Collector: 0.1 v/cm, H rate



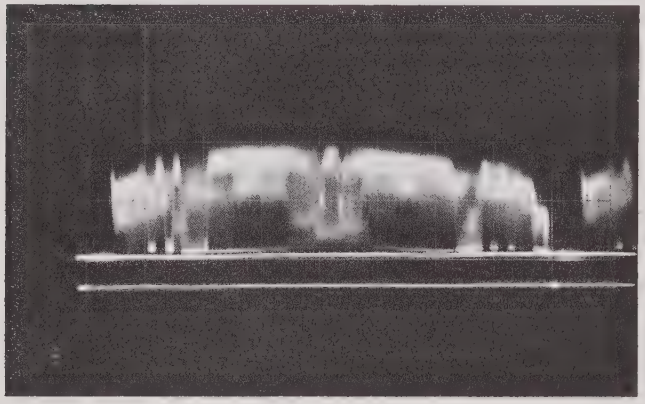
(b) Q9 Base: 1 v/cm, H rate



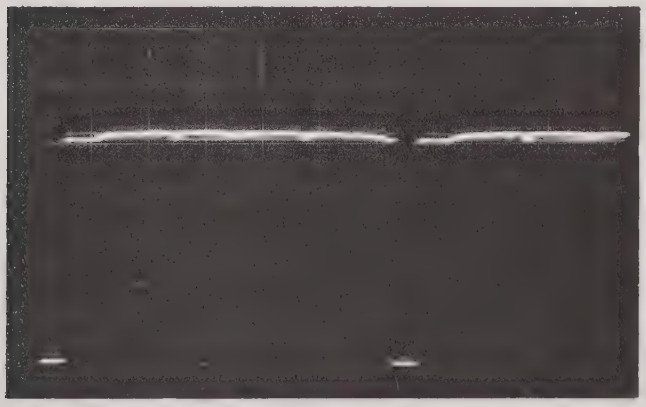
(c) Q12 Base: 5 v/cm, H rate

Fig. 22 Video Board Waveforms (a-c)

(d) Video Output Jack: 0.5 v/cm, H rate



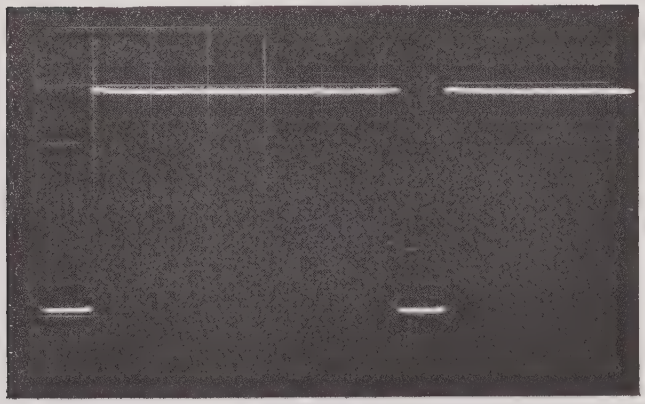
(e) Video Output Jack: 0.5 v/cm, V rate



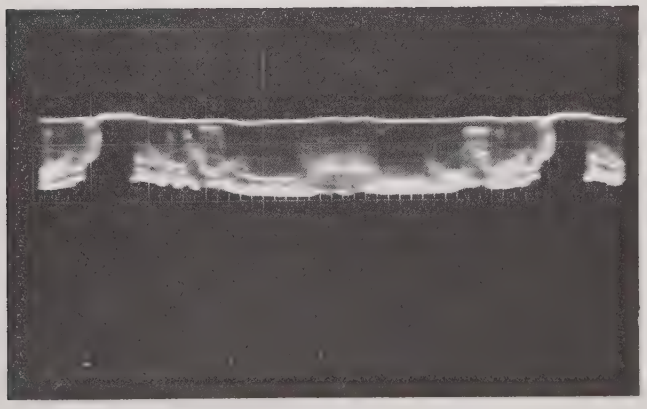
(f) Q22 and Q23 Collector: 5 v/cm, H rate

Fig. 23 Video Board Waveforms (d-f)

(g) CR4 Anode: 0.5 v/cm, H rate

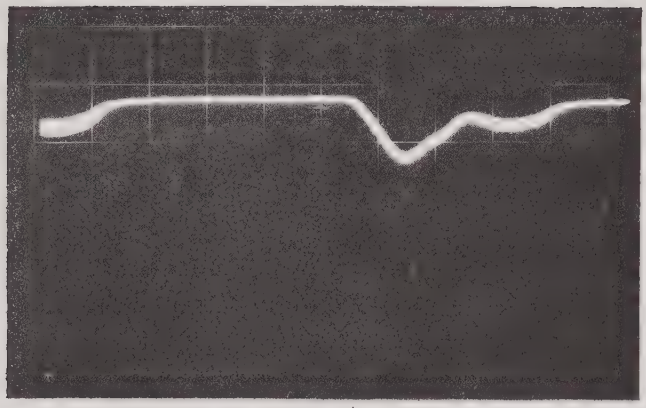


(h) Q19 Collector: 5 v/cm, H rate

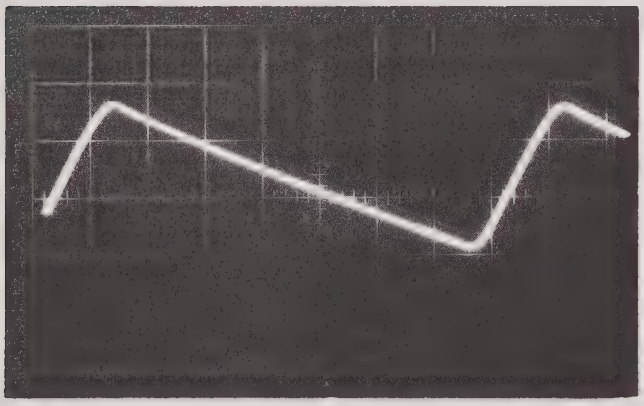


(i) Q18 Collector: 5 v/cm, V rate

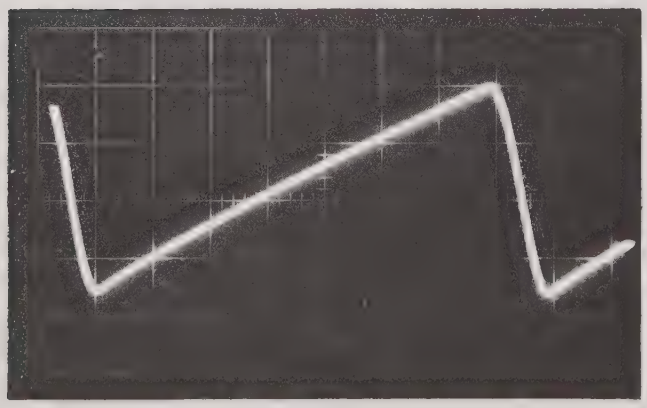
Fig. 24 Video Board Waveforms (g-i)



(j) Q16 Collector: 10 v/cm, V rate



(k) Plus Side of C28: 5 v/cm, V rate



(l) Minus Side of C27: 1 v/cm, V rate

Fig. 25 Video Board Waveforms (j-l)

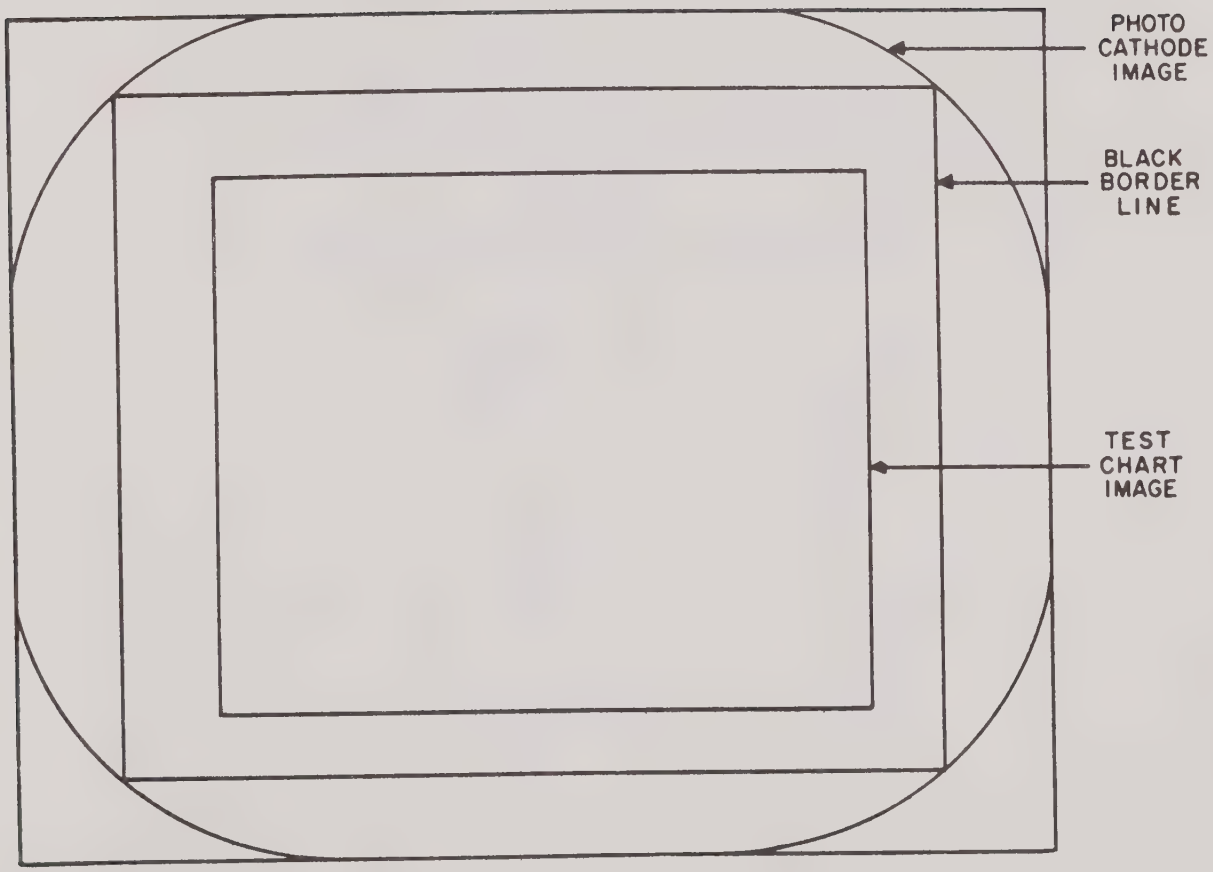
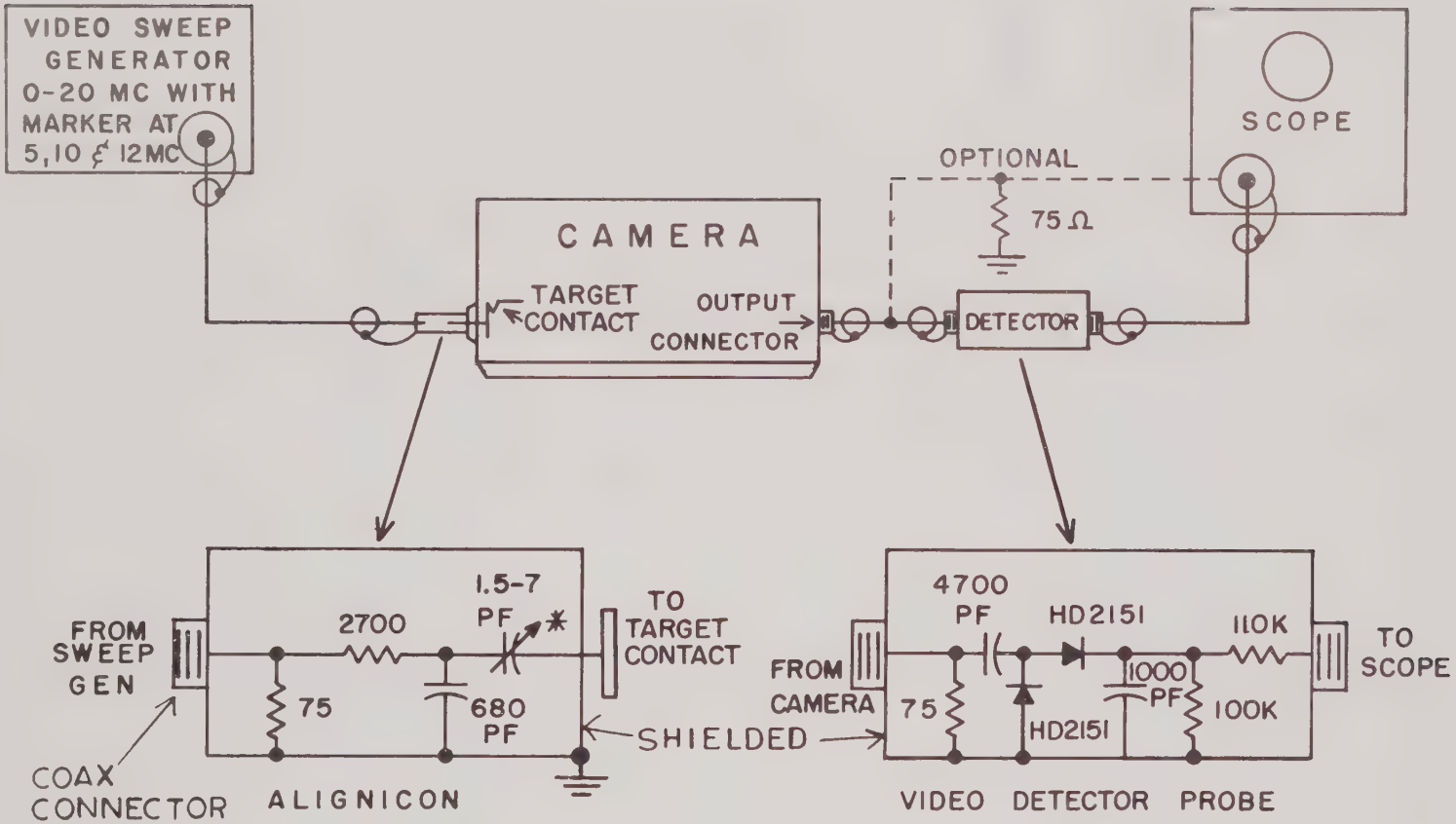


Fig. 26 Photocathode Image on Monitor Screen



* CONNECT TARGET CONTACT RING AND ALIGNICON CASE DIRECTLY TO A CAPACITY BRIDGE AND ADJUST THE 1.5-7PF TRIMMER FOR 9.0 PF.

Fig. 27 Equipment and Setup for Frequency Response Alignment

INSTRUCTIONS

FUNDAMENTALS OF TELEVISION AND ESSENTIALS OF OPTICS

EBI—3711

VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

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FUNDAMENTALS OF TELEVISION

The followng is a brief discussion of how a closed circuit television system functions. A closed circuit system is similar to the standard television broadcast system except that the picture information is transmitted to the picture screen by means of a coaxial cable instead of through space.

In a television system the first requirement is to generate an electrical equivalent of an illuminated subject or scene. See the Block Diagram, Closed Circuit Television System, Fig. 1.

The scene to be televised is focused, by means of a suitable lens, on the photoconductive-layer surface of the camera pickup tube. The resulting image is scanned by an electron beam in the camera tube, the amount of light the beam encounters at any instant determining the camera tube current. As a result of the camera tube scanning process, an output voltage proportional to the light intensity is obtained. The output voltage thus generated is called the video signal.

The video signal is amplified (strengthened) by video amplifiers in the Camera and applied to the Monitor, where it is converted from electrical to visual form, appearing on the Monitor screen as a picture.

In order for the Camera and Monitor circuits to work together (in synchronism), a synchronizing generator is included in the system. It generates pulses of electrical energy which are applied to both the Camera and the Monitor. The pulses from the synchronizing generator lock together the scanning beams in the Camera and the Monitor.

Camera Pickup Tube

The camera pickup tube used in a closed circuit monochrome camera is called a vidicon tube. In television broadcasting studios, larger pickup tubes with somewhat greater light sensitivity are used, but the size of the cameras and the cost of the tubes make their use impractical in an industrial television system, where maximum convenience and minimum maintenance costs are important.

Scanning System

The electron beam in the camera pickup tube, scans or sweeps across the image in an orderly fashion. In effect it divides the image into narrow horizontal strips, called lines. The beam scans each line from left to right, producing a video signal for each line, of which there are 525. In the Monitor,

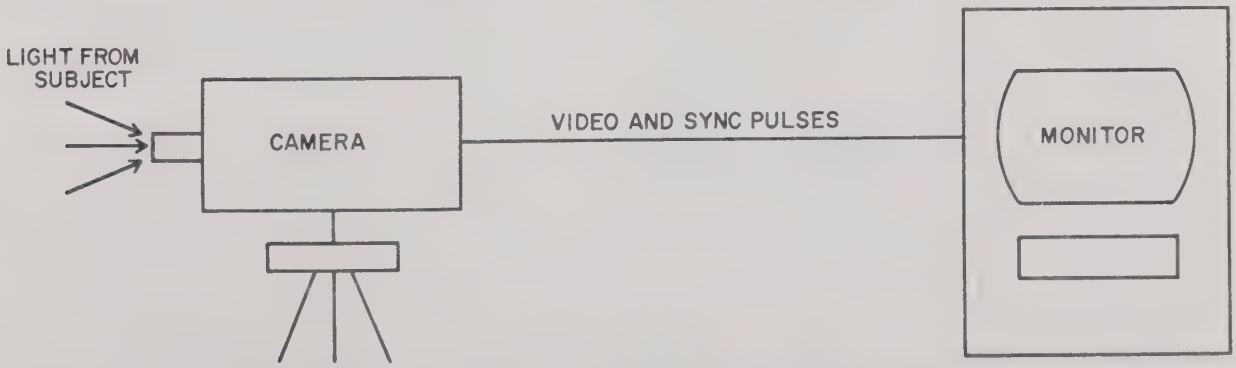

Fig. 1 Block Diagram, Closed Circuit Television System

the scanned lines are reassembled on the face of the picture tube in proper order. Fig. 2 illustrates the basic scanning principle. The scanning beam starts at the top left of the image and moves to the right and slightly downward at a uniform rate. When it reaches the end of the first line, it switches rapidly

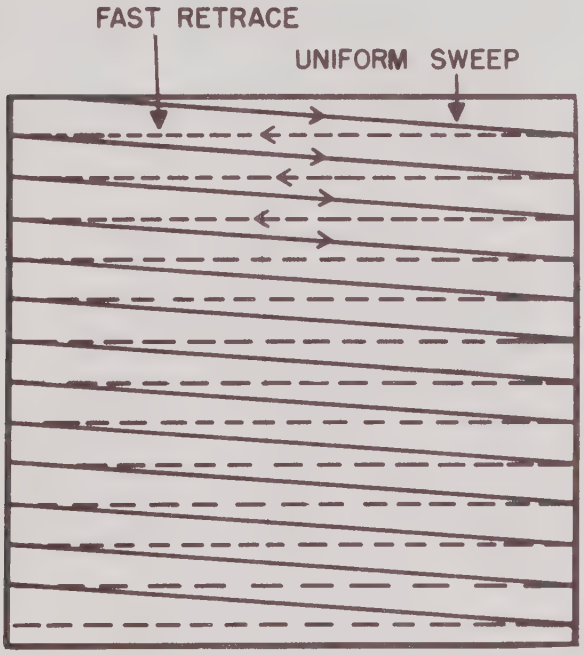

Fig. 2 Simple Non-Interlace Scanning Principle

back to the beginning of the second line. This fast return of the beam between each scanned line is called the retrace period. When the beam has scanned all of the horizontal lines and reaches the bottom of the image, it is rapidly returned to the top and the scanning process is repeated. The beam scans the image so rapidly that to the eye, no motion is apparent, and the lines blend into a complete picture. Note that no video signal is produced during the retrace period; in fact, in some monitors the picture tube beam is actually turned off during retrace.

The simple scanning system described above will produce a picture, but in practice a modified scanning method is used to reduce flicker. In the interlaced scanning system, the beam scans the image from left to right as before, but the horizontal lines are spaced apart by the thickness of one line. After one half of the 525 lines have been scanned, the beam is at the bottom of the image, and is returned rapidly to the top. It then scans the picture again, but the second set of lines are interlaced between the first set. The first set of horizontal lines is called the first field, while the second set is called the second field. The first field contains the first, third, fifth, seventh, and all succeeding odd numbered lines, and the second field contains the second, fourth, sixth, and all succeeding even numbered lines. Fig. 3 shows the interlaced scanning principle.

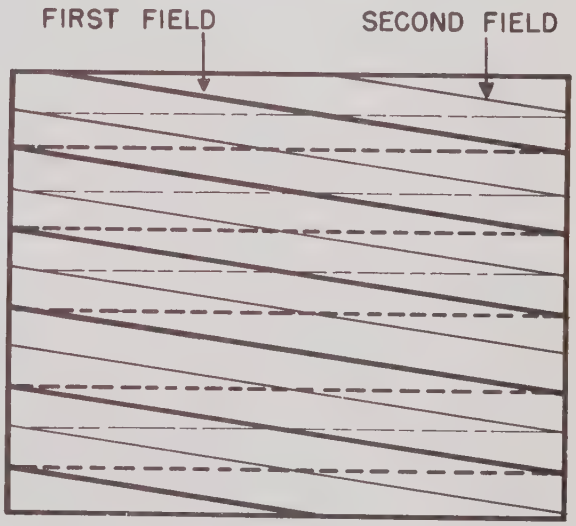

Fig. 3 Interlaced Scanning Principle

For each complete picture 525 lines are scanned ($262\frac{1}{2}$ lines during each field), which is termed a frame. Since 30 frames per second are scanned, 525 x 30, or 15,750 lines are scanned each second.

In the camera, sawtooth shaped pulses of electrical current are caused to flow through the vertical and horizontal windings of the camera deflection yoke. When the sawtooth pulses flow through the yoke coils, magnetic fields are set up which deflect the electron scanning beam in the desired scanning pattern. The horizontal sawtooth pulses recur 15,750 times each second and move the beam from left to right. The vertical sawtooth pulses recur 60 times each second and move

the beam from top to bottom. Fig. 4 illustrates the shape of the current sawtooth pulses which flow in the deflection yoke.

The previously mentioned sawtooth pulses from the synchronizing generator occur at the time when each sawtooth current must start to flow. Circuits in the camera sawtooth generator which generate the sawtooth pulses are triggered by synchronizing pulses, thus insuring that the vertical and horizontal scanning beam motions are interlocked.

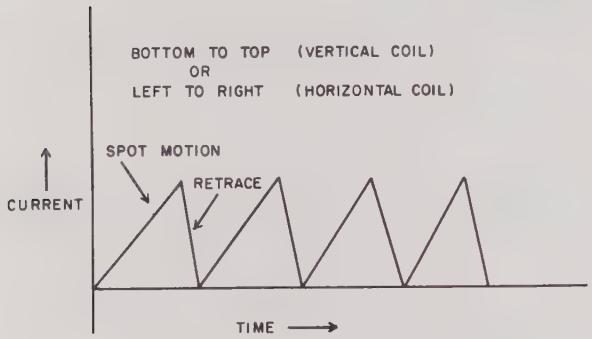

Fig. 4 Sawtooth Yoke Current

When horizontal triggering pulses are developed in a free running oscillator and vertical pulses are derived directly from the power line frequency, there is no positive interlocking of the horizontal (15,750) and vertical (60) frequencies. The difference in frequency between the oscillator and the power line may drift, over a period of time, due to small changes in oscillator and/or power line frequencies. This results in random interlace; that is; the lines of the second field may fall at random anywhere between the lines of the first field, and at times, on the lines of the first field.

The Video Signal

The video signal from the vidicon tube is amplified by video amplifiers in the Camera. Fig. 5 depicts the shape of the video output voltage. Note that the video voltage for only one of the 525 scanned lines is shown.

The output of the Camera contains only the video signal with added horizontal and vertical synchronnizing pulses. The pulses serve to keep the Monitor scanning beam in step with the Camera scanning beam, and also turn the Monitor beam off during the retrace periods.

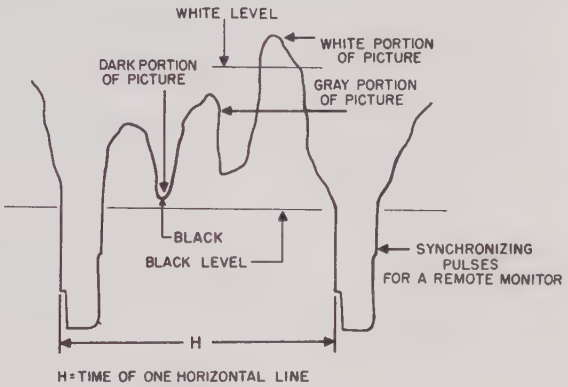

Fig. 5 Video Signal of One Horizontal Line

Monitor

The Monitor converts the electrical video signal from the video chassis into an image on the screen of its picture tube.

The picture tube has an electron scanning beam which is controlled by sawtooth pulsed currents flowing in a deflection yoke. The beam strikes the screen of the picture tube, which is coated with a fluorescent substance, and makes the coating glow. The strength of the beam is controlled by the video signal, resulting in a recreation of the original scene on the screen. Of course, the sawtooth pulses flowing in the Monitor deflection yoke are also timed by the synchronizing pulses so that the beam in the Monitor is moved in synchronism with the beam in the Camera.

ESSENTIALS OF OPTICS

The camera lens is used primarily to focus an image of a desired scene on the photosensitive surface of the camera pickup tube. Two basic characteristics of a camera lens are the focal length and the lens speed designation. The focal length is the distance from

the optical center of the lens to the point behind the lens where the scene is focused. Therefore, if an object at infinity is focused at a point two inches behind the lens, the focal length (F.L.) is two inches. Usually, the greater the F.L. the greater the physical length of the lens barrel.

The focal length governs the image magnification and the angle of field covered. Longer F.L. lenses make distant objects appear "close-up", thus enlarging the produced image. When longer focal length lenses are used, the field of coverage is less. When the subject to be reproduced is larger than the field of view of the lens, either the subject or the camera will have to be moved back, or a shorter focal length lens used to obtain a greater angle.

Horizontal and vertical field coverage for a given F.L. lens has a direct relation to the scanned area of the photoconductive surface upon which the image is focused. Refer to the ratios below.

$$\frac{\text{F.L.}}{\text{Scanned Area Width}} = \frac{\text{Distance of Subject From Lens (feet)}}{\text{Width of field (feet)}}$$

The standard television aspect ratio is three units high and four units wide, and the scanned area of the light sensitive element of the vidicon is 3/8 inch high by $\frac{1}{2}$ inch wide to correspond to this ratio. Therefore, since the vidicon scanned area width equals $\frac{1}{2}$ inch, the above equation can be written as follows:

$$W = \frac{0.5 \times D}{\text{F.L.}}$$

where W = Width of field (feet).
D = Distance of subject from lens (feet).
F.L. = Focal length (inches).

The height of field (feet) viewed by the lens will be:

$$H = 3/4 \times \text{width of field}$$

The following examples will show how the above equations may be used.

EXAMPLE 1

The camera is equipped with a one-inch focal length lens and the scene to be viewed is located 20 feet from the camera. What area will be viewed by the camera?

$$W = \frac{0.5 \times D}{\text{F.L.}} = \frac{0.5 \times 20}{1} = 10 \text{ feet}$$

$$H = 3/4 \times W = 3/4 \times 10 = 7.5 \text{ feet}$$

As shown, the camera will view an area 10 feet wide and 7.5 feet high.

The same formula can be used to determine the necessary distance from the camera to a scene of a given width to be viewed. Using the above equation.

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{10 \times 1}{0.5} = 20 \text{ feet}$$

EXAMPLE 2

A scene 30 feet wide is to be viewed with a camera having a 0.5-inch F.L. lens. What is the distance from the scene to the camera?

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{30 \times 0.5}{0.5} = 30 \text{ feet}$$

EXAMPLE 3

The following example will show how the F.L. of a lens may be determined.

A scene to be viewed is 20 feet wide, but the camera cannot be located more than 30 feet from the scene. What F.L. lens is required?

$$\text{F.L.} = \frac{0.5 \times D}{W} = \frac{0.5 \times 30}{20} = 0.75 \text{ inch}$$

If a 0.75-inch lens is not available, the next smaller size, which is a 0.5-inch F.L. lens, will have to be used. At a distance of 30 feet the 0.5-inch lens will actually view a width of 30 feet, as obtained from the equation below.

$$W = \frac{0.5 \times 30}{0.5} = 30 \text{ feet}$$

Since it is only necessary to view 20 feet of the scene width, the distance from the camera to the scene will be

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{20 \times 0.5}{0.5} = 20 \text{ feet}$$

Therefore, the camera should be located 20 feet from the scene being viewed, and equipped with a 0.5-inch F.L. lens.

The above mentioned examples may be solved at a glance by using the Subject Width vs. Subject Distance charts, Figs. 6 and 7. When using the charts be sure the F.L. of the lens corresponds to the F.L. of the chart being used.

To solve the examples using the charts, proceed as follows.

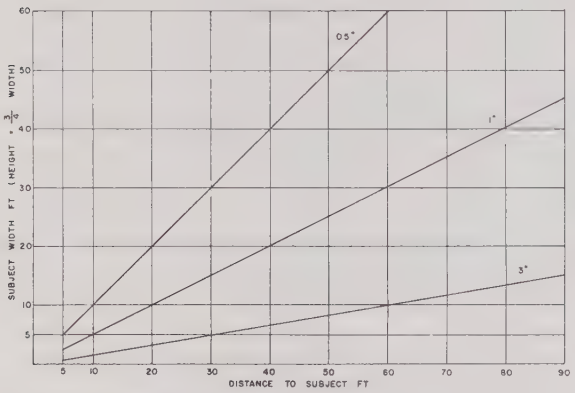

Fig. 6 Subject Width vs. Subject Distance for 0.5-Inch, 1.0-Inch, and 3-Inch Lenses

EXAMPLE 1

Locate the intersection of the one-inch lens line and the 20-foot distance line. Extend this point horizontally until it intersects with the Subject Width axis. As shown on the chart, the width is 10 feet. The height is 3/4 x 10 or 7.5 feet.

EXAMPLE 2

To determine D, locate the intersection of the 30-foot width line and the 0.5-inch F.L. lens line. Drop this line down to the distance axis. As shown, the distance is 30 feet.

EXAMPLE 3

Locate the intersection of the 20-foot width line and the 30-foot distance line. This point lies half-way between the one-inch lens line and the 0.5-inch lens line. Therefore, the 0.5-inch lens must be used. As shown in Fig. 6, a 0.5-inch F.L. lens views an area 30 feet wide. If an area 20 feet wide is to be viewed using a 0.5-inch lens, the distance from the camera to the scene being viewed is 20 feet.

The lens manufacturer normally supplies a booklet with each lens. This booklet contains a data chart which gives the height and width of the area covered by the lens at various distance settings.

The focal length of some lenses may be stated in millimeters (mm). The above mentioned equations and charts are applicable only when the F.L. is expressed in inches. One inch is equal to 25.4 mm, therefore to convert mm to inches use the equation below.

$$\frac{\text{millimeters}}{25.4} = \text{inches}$$

For example, a 50 mm F.L. lens is equal to $\frac{50}{25.4}$ inches, or approximately a two-inch F.L. lens.

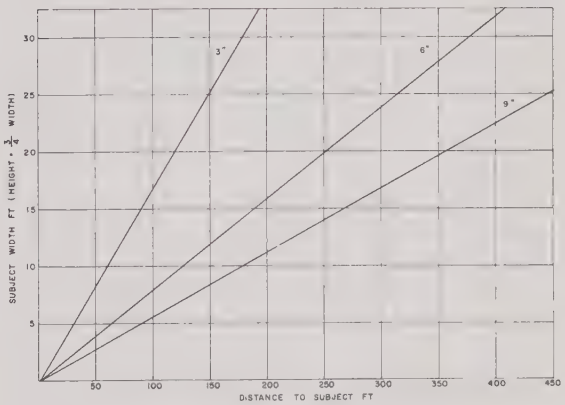

Fig. 7 Subject Width vs. Subject Distance for 3-Inch, 6-Inch, and 9-Inch Lenses

The second lens characteristic is lens speed designation. More light will be transmitted by a lens when the effective lens diameter is increased and the lens designation is decreased. Most lenses have an adjustable iris so that the effective diameter of the lens can be controlled. The lens iris performs the same function as the iris of the human eye. When the eye suddenly sees a bright scene, the iris automatically closes to admit less light, thereby preventing temporary blindness. In a television system the camera tube operates over a limited range of brightness. Any sudden increase of light may cause the camera tube to become inoperative since the lens iris is not an automatic device (unless

the camera is equipped with an Automatic Iris Control); therefore, the lens iris must be adjusted manually.

As mentioned above, the lens speed designation is a function of the F.L. and may be calculated by the following equation.

$$\text{Lens speed designation (f)} = \frac{\text{F.L.}}{\text{D}}$$

Where F.L. = Focal length of lens (inches)
D = Lens diameter with the iris at its widest opening (inches).

For example, a one-inch lens that has an iris opening of 0.66 inch will have a lens speed designation of 1.5 as shown in the equation below.

$$\text{f} = \frac{1.0}{0.66} = 1.5$$

When lens speed is referred to, one lens is said to be "faster" or "slower" than another lens. The "faster" lens will have a lower lens speed designation or f number, and will pass more light (iris opening of the "faster" lens is larger). THE f NUMBER OF A LENS INCREASES AS THE IRIS DIAMETER IS DECREASED.

For example, compare the light passing capabilities of two lenses, or two f numbers on the same lens, such as f1.5 and f3.0. The f1.5 lens will admit more light than the f3.0 lens. Actually the amount of light varies inversely as the square of the f number ratio. In this example the f3.0 lens will pass $\left(\frac{\text{f1.5}}{\text{f3.0}}\right)^2$, or one quarter as much light as the f1.5 lens.

Most lenses are equipped with the following adjustments:

FOCUS RING ADJUSTMENT - Adjusts for sharpest focus, calibrated in feet.

IRIS RING ADJUSTMENT - Adjusts iris diameter, calibrated in f numbers.

In general the iris is set to its widest opening (lowest f number) for low light levels, and is "stopped down" (iris closed further) when the scene illumination increases above normal. In addition to changing the amount of light passed through a lens, variations of the iris diameter will also affect the depth of field of the lens. This effect is especially noticable on scenes or objects near the camera. A certain portion of the scene will be in focus. However, objects nearer to and farther away from the camera will be out of focus. The depth of field pertains to the portion of the scene that is in focus, and is measured by the distance from the nearest to the farthest points in focus. The factors which affect the depth of field are:

FOCAL LENGTH - Depth of field increases with shorter focal length lenses.

f STOP NUMBERS - Depth of field increases as the f number increases.

DISTANCE FROM LENS TO OBJECT IN FOCUS - Greater distances will result in greater depth of field.

The depth of field varies with the f number, focal length, and certain design characteristics of the lens (such as telephoto and wide-angle). The manufactures's booklet supplied with the lens contains data tables which give the depth of field for various combinations of f numbers and focus distance. Some lenses have a depth of field scale built into the lens mounting. This shows the approximate depth of field at all distances and f number stops.

INSTRUCTIONS

FUNDAMENTALS OF THE VIDICON TUBE AND TRANSISTOR CHARACTERISTICS

EBI—3781A

VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION
GENERAL ELECTRIC
ELECTRONICS PARK, SYRACUSE, N. Y.

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INSERT

Vidicon Tube Bulletin

FUNDAMENTALS OF THE VIDICON TUBE

The structural arrangement of and additional information about the vidicon tube can be found in the Vidicon Tube Bulletin, located in the back of this book.

The photoconductive layer of the vidicon tube is made up of many small elements, each of which is essentially an insulator in the dark, but conductive when illuminated. The target (signal electrode) ring makes contact with the front side of the layer and is maintained at a positive potential. A beam of electrons from the vidicon electron gun (cathode and grids #2, #3, and #4) scans the rear side of the layer, and the scene to be televised is focused on the front. Since the amount that the photoconductive layer will conduct is dependent on the level of illumination reaching it, each element on the rear side of the layer will rise toward the positive target voltage. Thus, a positive voltage pattern corresponding to the focused scene is deposited on the rear side of the layer. The electron gun beam produced by the electron gun scans this voltage pattern, deposits enough electrons on the back side of the photoconductor layer, and reduces them to the vidicon cathode potential.

Each photoconductor element may be considered as a capacitor with one plate connected to the positive target voltage and the other plate grounded. Each plate contains internal resistance proportional to the amount of illumination striking it. Since the two sides of the photoconductive layer are connected by the external target circuit and the electron beam, a capacitive video signal current is produced. Increasing or decreasing the target voltage or the illumination of the vidicon tube will cause a corresponding increase or decrease in the video output signal from the vidicon tube.

The TARGET control can be considered as a sensitivity or gain control for the vidicon tube and will affect the output. With a given light level, increasing the target potential (clockwise rotation) will increase the output. However, there is a limitation in the extent the target voltage can be increased. If the target voltage is increased excessively, a bright ring will appear around the outer edges of the photoconductive layer. As the photoconductive layer is not a perfect insulator in the dark, a small amount of dark or leakage current will occur. The dark current is greater around the circumference of the photoconductive layer than in the center and visually appears as a white ring (edge flare) around the edge. See Fig. 1(c). When the target voltage is increased, the edge flare increases, and when the target voltage is increased far enough, edge flare will be visible in the monitor picture. Therefore, a certain target control setting will represent the vidicon sensitivity with unobjectionable edge flare. This setting is called the optimum sensitivity of the target control for a particular vidicon tube.

The BEAM control varies the amount of the negative voltage on grid #1 of the vidicon tube and thus controls the strength of the electron beam. As previously stated, the television scene is represented by a positive voltage pattern, the higher illuminated portions being more positive. Therefore, sufficient electrons must be supplied to discharge (reduce to ground potential) the highest illuminated parts of the photoconductive layer. If the strength of the electron beam is increased excessively beyond this point, distortion of the picture will result. Too little beam current will result in loss of detail in the more highly illuminated areas of the scene being viewed.

A characteristic of the vidicon tube is its tendency to retain the image of a subject when either the Camera or subject moves. When this occurs, the image of the subject appears blurred (as seen on the monitor screen). This characteristic can be decreased by increasing the illumination on the sub-

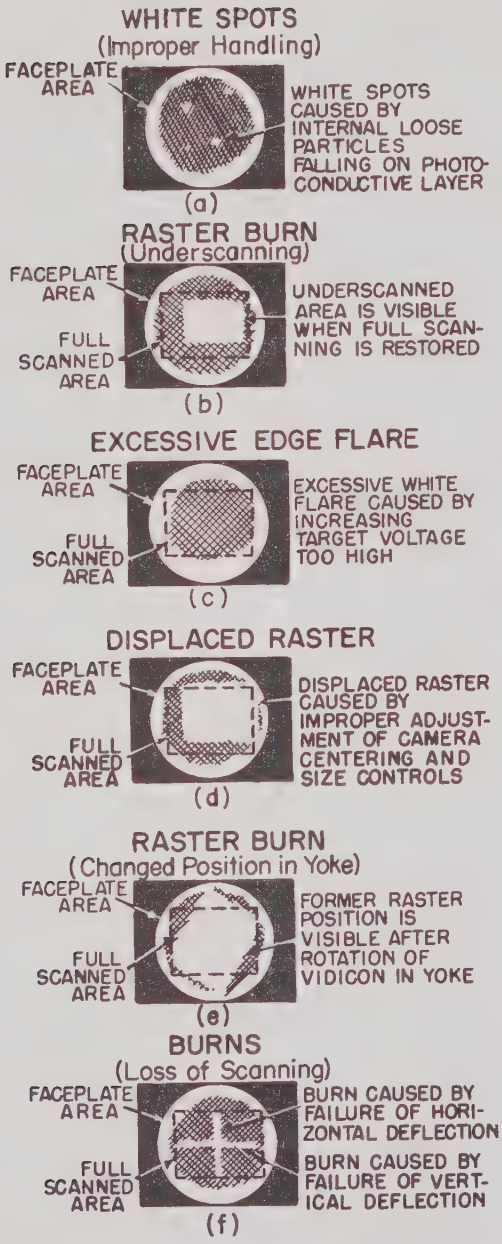

Fig. 1 Vidicon Defects Resulting from Improper Handling

ject. The vidicon photoconductive layer is deposited on the circular faceplate of the tube. The diameter of this layer is 3/4 inch. However, the useful scanning area of the photoconductive layer is a rectangle 3/8 x 1/2 inch. If an area greater than or displaced from the 3/8 x 1/2 inch rectangle is scanned, the tube is operating outside its specified limits. Scanning an area less than the 3/8 x 1/2 inch quality area (underscanning) will generally result in pictures of reduced resolution as well as possible tube damage. Underscanning should be avoided at all times.

Due to the semiconductor nature of the photoconductor, certain inherent properties make it important to utilize the full 3/8 x 1/2 inch scanning area, being careful not to exceed or fall outside it. During scan, a layer conditioning takes place which results in extra sensitizing of the scanned area. This extra sensitizing is commonly referred to as raster burn, a normal characteristic of vidicon tubes. Raster burn appears on the monitor screen as a light-toned area. Thus, if too small an area is scanned initially and a larger area is scanned later, the smaller underscanned area will appear light and framed within the larger scanned area.

Similarly, if after initial use the vidicon tube is rotated, use in the new position will reveal a raster burn at an angle to horizontal.

Overscanning is not harmful to the tube, but since it involves an area larger than the rectangular 3/8 x 1/2 inch quality area, it may result in a picture showing edge flare and/or blemishes outside the quality area.

The correct procedure for obtaining the 3/8 x 1/2 inch quality area on the photoconductive layer of the tube is outlined in the Camera and Sweep Adjustments section under MAINTENANCE in the Camera instruction book. After the quality area is obtained, further adjustment of the Camera controls (size, centering, alignment), should be avoided. If the position of the tube is changed, a raster burn may result. Refer to Fig. 1(e). Therefore, changing the tube position should be avoided.

Vidicon Precautions

The following precautions should be observed when handling or operating the vidicon tube.

1. When handling the vidicon, always keep it in a horizontal or vertical position with the faceplate up.

2. Adjust the Camera scanning to utilize the maximum useful area of the photoconductive layer.

3. Match any visible raster pattern on the photoconductive layer with new scan.

4. Align the electron beam.
5. With the lens capped, adjust the target voltage for each individual vidicon to the highest value that will still give a uniform background.
6. Open the lens iris or increase the scene illumination to obtain the snappiest picture without noticeable smear from moving objects.
7. Use only sufficient beam current to bring out picture highlights.
8. Always cap the lens when transporting the Camera.

CAUTION

NEVER ALLOW AN IMAGE OF THE SUN TO BE FOCUSED ON THE PHOTOCONDUCTIVE LAYER AT ANY TIME.

9. Never operate or transport the Camera with the faceplate in the down position, unless a vidicon with a particle shield such as the 7226 or 7262A is being used. Refer to Fig. 1(a).
10. Never underscan the photoconductive layer. Refer to Fig. 1(b).
11. Never change the Camera size and centering controls once the scanned area of the photoconductive layer has been properly positioned. Refer to Fig. 1(d).
12. Never rotate the vidicon from its original operating position in the deflecting yoke. Refer to Fig. 1(e).
13. Never turn the beam or the vidicon on without normal scanning. Refer to Fig. 1(f).

TRANSISTOR CHARACTERISTICS

The most common semiconductor devices, and those to be found in General Electric Closed Circuit equipment, are diodes, transistor triodes, and transistor tetrodes. All may be constructed of the two most used semiconductor materials, germanium and silicon.

While comparisons between semiconductor devices and vacuum tubes result in useful analogies, these should not be carried too far, since transistors have many characteristics which have no counterpart in vacuum tube technology.

The major advantages of transistors over vacuum tubes are their small size, mechanical rigidity, and very modest power requirements.

A comparison of vacuum tubes and junction transistors reveals one of the most significant differences. The impedances in transistor circuits are much lower than in vacuum tube circuits. That is to say, transistors are current operated rather than voltage operated. The transistor electrode most analogous to the tube control grid (the base) draws measurable current from its bias and signal sources. Because of this characteristic, the design of transistor circuits requires a new approach.

In addition, two general types of transistors are available: NPN and PNP. See Fig. 2.

Note the comparison between the base and grid, emitter and cathode, and collector and plate. Also of note is that the NPN transistor requires a positive potential on its collector as does the vacuum tube on its plate. Since the PNP transistor requires a negative collector potential, no direct vacuum tube analogy exists, although the base, emitter, and collector functions remain analogous.

For a complete introduction to transistors and circuits, it is recommended that a copy of the General Electric Transistor Manual (latest edition) be purchased from a General Electric tube and transistor dealer.

Trouble Shooting

The trouble shooting techniques in this book are applicable to all General Electric Closed Circuit Television transistorized equipment.

Elementary Diagrams in the respective instruction books are representive of major sections, and therefore will facilitate trouble shooting.

With the help of the Elementary Diagrams, oscilloscope waveforms, d-c socket voltages, and trouble shooting charts, it should be

possible to locate the more common faults which can occur.

Note that localization of faults does not differ from vacuum tube equipment of similar nature.

A few differences between vacuum tube and transistor circuits, which may prove valuable to know, follow.

Vacuum tubes generally operate with plate potentials in the range of 100 to 300 volts. Transistor collector potential ranges from two or three volts to 50 volts.

The control grid in a Class A vacuum tube circuit is several volts removed from the cathode. However, in a Class A transistor stage, the base and emitter will be about 0.2 volt apart (germanium) and about 0.6 volt apart (silicon). Note, however, that in some circuits in the equipment the transistors are used as switches and the base is not necessarily clamped to the emitter in this way.

Since transistors operate with such small voltage differences between terminals, it becomes important to search for smaller voltage errors when trouble shooting transistor stages than experience with tubes would indicate.

When using an oscilloscope for waveform analysis, it is seldom necessary to use a high impedance probe, since the impedance level in transistor circuits is relatively low.

It is most important to guard against accidental shorting of components with screwdrivers, 'scope leads etc., in transistorized equipment because semiconductor devices are easily and permanently damaged by momentary application of incorrect potentials.

Testing Transistors

Transistors are more easily ruined than vacuum tubes by improper testing or by the application of improper potentials in a faulty circuit. For this reason it is recommended that the following suggestions be carefully heeded.

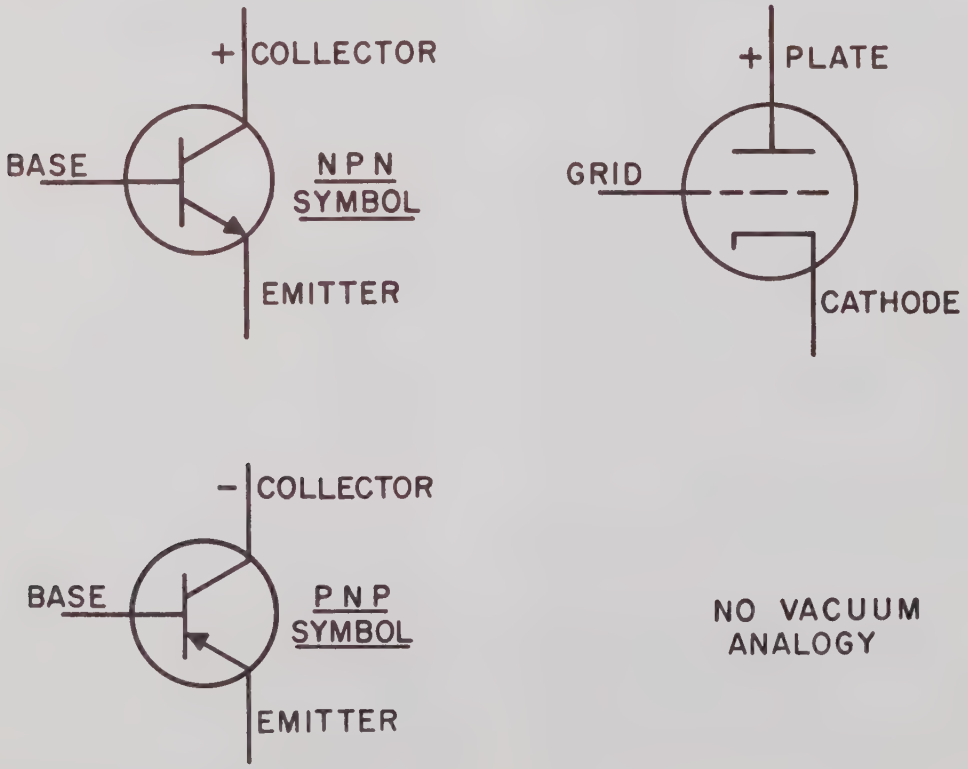

Fig. 2 NPN and PNP Transistors Compared to the Vacuum Tube

In general, it is inadvisable to attempt transistor checking with an ohmmeter, because the battery built into the meter may apply a potential to the transistor electrodes which exceeds the transistor rating.

It has been found that one of the most important characteristics of a transistor is the a-c current gain, designated h_{fe}, or beta. Beta applies when a transistor is connected in the common emitter configuration.

Another characteristic is known as base-collector leakage current, designated I_{co}. I_{co} should be as small as possible and is a measure of transistor quality. Beta and I_{co} vary with different transistor electrode potentials which makes it advisable to check a transistor with the collector voltage, collector current, and base current which prevail in the circuit in which it is to be used.

A commercial transistor checker is a wise investment if transistorized equipment is to be maintained, particularly if rapid trouble shooting is required. This is not to imply that transistors are not reliable or that they have short life under normal conditions. Normally transistors have a much longer life than vacuum tubes. However, a faulty circuit component or a power supply voltage out of specifications can cause application of potentials to a transistor which could cause its untimely demise.

A transistor checker may be simple or refined, but even the simplest is useful and indicates beta and I_{co}. An example of a simple checker is the Triplett Model 690A. Another unit, the Armour Electronics Model T-340 is an example of the more refined checker.

For additional information on transistors, their theory, application, and characteristics, refer to the General Electric Transistor Manual (Seventh Ed. 652 pages) available for $2.00 from most G. E. Authorized distributors and dealers, or from the General Electric Co., 1 River Road, Schenectady, New York.

E.B.I. 6286

Model 4TE26A1
4TE26B1

Authorization GE-3424~~6~~64-35

PRODUCTION CHANGE NO. 1

Parts List 7699908G1 Power/Sweep Board

Schematic Diagram 7699913 (Fig. #7)

Symbol No.		Description	Effective Serial No.
4R94	Added	Resistor, Comp.; 6800 ohm ±5% 1/4 w (GE-3R152P682J)	#1

Change schematic diagram (Fig. #7) by adding "4R94 - 6.8 K" in parallel with L2.

11/25/69

E.B.I. 6286

Model 4TE26A1
4TE26B1

Authorization GE-34264-37

PRODUCTION CHANGE NO. 2

Parts List 7699908G1 Power/Sweep Board

Schematic Diagram 7699913 (Fig. #7)

Symbol No.	Description		Effective Serial No.
	Change From	Change To	
	Resistors (comp.; ±5%,1/4 w unless otherwise specified)		
4R20 & 4R22	2200 Ohms (GE-3R152P222J)	1800 ohms (GE-3R152P182J)	Starting with #158 on 4TE26A1A
			and
4R79	2200 ohms, 1/2 w (GE-3R77P222J)	2200 ohms (GE-3R152P222J)	Starting with #267 on 4TE26A1B

Change schematic diagrem (Fig. 7) to agree.

In Fig. 27, change "680 pf" in alignicon to "220 pf".

12/4/69

E.B.I. 6286

Model 4TE26A1
4TE26B1

Authorization GE-34264-38

PRODUCTION CHANGE NO. 3

Parts List 7699908G1 Power/Sweep Board

Schematic Diagram 7699913 (Fig. #7)

Symbol No.	Description		Effective Serial No.
	Change From	Change To	
4R35	Resistor; Composition, 0.10 megohm ±5%, 1/4 w (GE-3R152P104J)	Resistor; Composition, 47,000 ohms ±5%, 1/4 w. (GE-3R152P473J)	Starting with #157 on 4TE26A1A, #172 on 4TE26A1B & #192 on 4TE26A1E

Change schematic diagram (Fig. #7) to agree.

Parts List 7699910G1 Interconnection Board

Schematic Diagram 7699911 (Fig. #14)

1R8	Added	Resistor; Composition, 3.3 megohms ±5%, 1/4 w. (GE-3R152P335J)	

Change schematic diagram (Fig. #14) by adding "1R8 - 3.3 meg." in parallel with 1VR[2].

/gr
12/19/69

E.B.I. 6286

Model 4TE26AI
4TE26BI

Authorization GE-342~~64~~-45

PRODUCTION CHANGE NO. 4

Parts List 7699908GI Power/Sweep Board

Schematic Diagram 7699913 (Fig. #7)

	Description		Effective Serial No.
	Change From	Change To	
	Resistors (Composition, ±5% 1/4W.)		
4R70	1000 ohms (GE-3RI52PI02J)	750 ohms (GE-3RI52P75IJ)	See Note below.
4R73	1000 ohms (GE-3RI52PI02J)	220 ohms (GE-3RI52P22IJ)	
4R95	Added	5600 ohms (GE-3RI52P562J)	

Change schematic diagram (Fig. #7) to agree.

NOTE: 4TE26AID - starting with #205

4TE26AIE = #192, 197, 199, 200, 225 and all following cameras

All other TE26A & B cameras - starting with #277.

/gr
1/22/70

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